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FINAL REPORT ON GRAVITY SUBSTITUTE WORKBENCH (SKYLAB EXPERIMENT - M507)

SPACE DIVISION CHRYSLER CORPORATION

FINAL REPORT ON GRAVITY SUBSTITUTE WORKBENCH
(SKYLAB EXPERIMENT-M507)

CONTRACT NAS8-21385

Prepared for

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ABSTRACT

This report covers the effort expended by the Chrysler Corporation Space Division under Contract NAS8-21385 covering the study, development, and design of a gravity substitute workbench using both the electrostatic and the aerodynamic principles; and also the fabrication and testing of flight configurations of the electrostatic workbench for use in the Skylab program.

Although all aspects of safety (such as ozone, X-ray, and ultra-violet) were not proven, it was demonstrated that injurious electrical shock could not be experienced in using this equipment. However, the operator should be furnished with a suitable grounding strap to preclude experiencing an occasional mild shock that can occur under certain conditions.

The design was proven by functional and environmental testing to be satisfactory. Some erratic results, however, were noted in the electroadhesive forces obtained. Further study, development, and testing is recommended to achieve optimum and consistent results.

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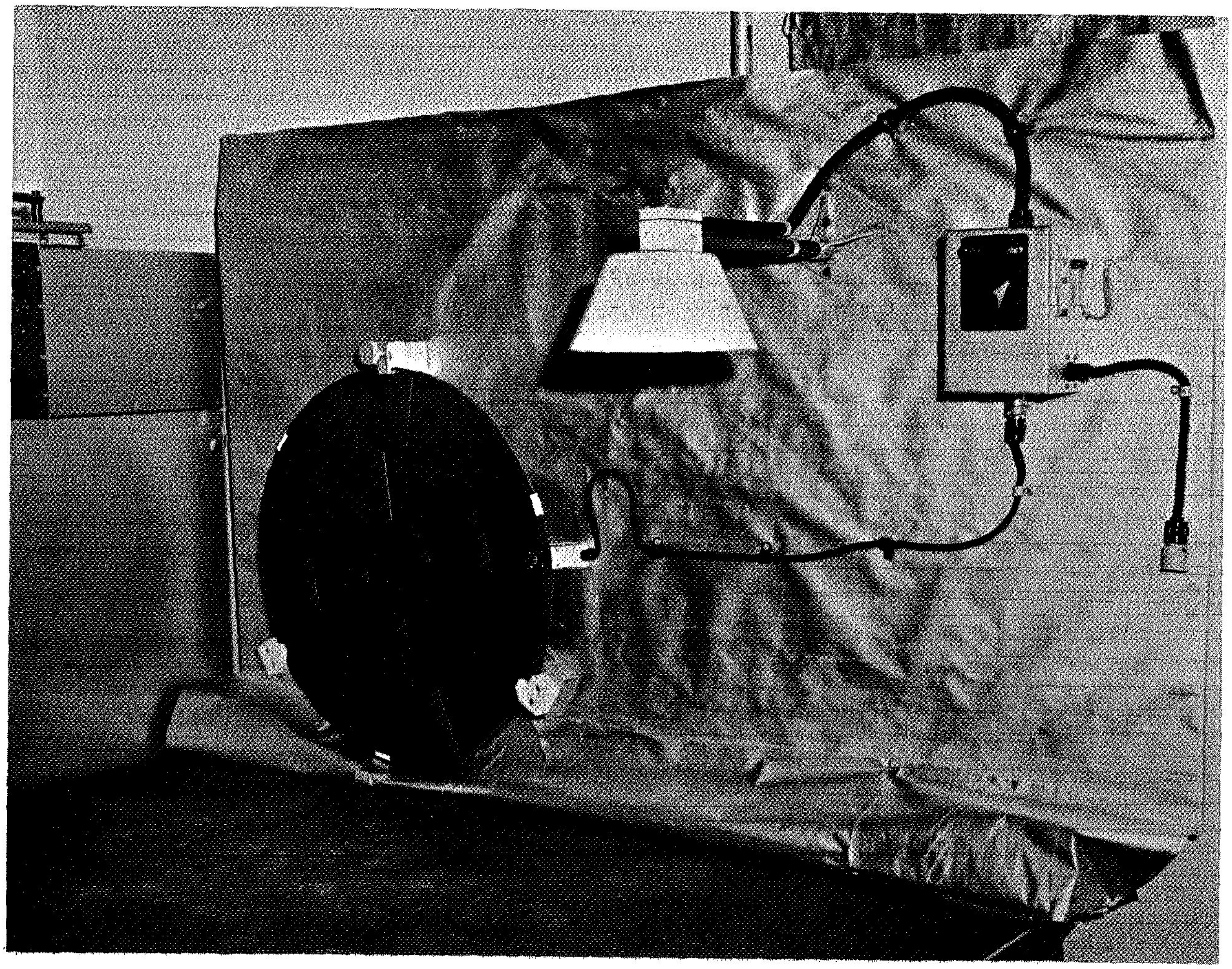


Electrostatic Workbench Stowage Condition

Section 1

SUMMARY

1.1 INTRODUCTION

This report summarizes the results of effort expended by Chrysler Corporation Space Division on the study, development and design of a gravity substitute workbench utilizing both the electrostatic and the aerodynamic principles, and also the fabrication and testing of flight configurations of the electrostatic workbench for use in the Skylab program. This program was funded under Contract NAS8-21385.

1.1.1 Background

It has been recognized for some time that the zero-g environment of an orbiting space station could offer many disadvantages as well as some advantages when assembly or maintenance work must be accomplished. Operations involving hand tools and small parts of intricate assemblies would be particularly troublesome since the astronaut's attention to the task at hand would be distracted by the need to secure these tools and parts.

Forces which may be employed in a work station facility to simulate gravity are centrifugal, magnetic, electromagnetic, and adhesive. These substitutes are somewhat limited in that they may involve excessive weight or power penalties, or would only be effective for magnetic objects, or might not be suitable for long-term space use. During the early planning for candidate experiments to be flown on the Apollo Applications Program Orbiting Workshop (now Skylab), it was decided that aerodynamic and electrostatic forces might offer advantages which could be developed into practical workbench designs. A study contract for the Aerodynamic Workbench concept was awarded to Nortronics-Huntsville in 1967 and resulted in the establishment of preliminary design criteria and the procurement of impellers, motors, and speed controls. A somewhat similar contract, but without hardware procurement, was awarded to Chrysler Corporation Space Division in June 1968 for the Electrostatic Workbench concept. This award was based upon Chrysler's previous work in electrostatics and development of the "electroadhesor" in 1966. In the meantime the Gravity Substitute Workbench Experiment M507 was established under the sponsorship of NASA-OMSF with MSFC as the Payload Integration Center. The Experiment Implementation Plan was issued on July 5, 1968 to summarize the criteria and planning information as of that time for both workbench concepts.

1.1.2 Contract Scope

A contract (NAS8-21385) was written to cover the initial scope of work (Phase I - Study) and has since been modified by supplementary agreement to broaden the scope as progress was made and funding could be authorized. The original contract (NAS8-21385) was to conduct a predesign investigation consisting of mathematical analyses, studies, and experimentation necessary to establish criteria for use in the formal design and reliability analysis of an electrostatic workbench, thereby insuring the safety and usefulness of this method of gravity substitution. The original contract, awarded June 4, 1968, is known as Phase I - Study. Subsequent modifications to the basic contract were as follows:

a. Modifications 1 through 4 consisted of minor revisions to contract language and extensions to the period of performance.

b. Modification 5 impacted both the Electrostatic and the Aerodynamic Workbench.

   1) Electrostatic Workbench. Utilize the criteria developed under Phase I to document the design of a safe and useful gravity substitute. The working surface had to be circular and interface with the working surface of the Aerodynamic Workbench.

   2) Aerodynamic Workbench. Utilize the design criteria and configuration developed by MSFC to document the design of a safe and useful gravity substitute having a 24-inch diameter working surface.

   A preliminary design of both workbenches was to be developed and approved prior to documenting the formal design. It was awarded May 26, 1969 and is known as Phase II - Design.

c. Modification 6 covered fabrication and testing of an engineering prototype of the electrostatic workbench as a development tool in establishing the formal design. This modification was awarded on August 12, 1969 and is known as Phase IIA - Engineering Prototype.

d. Modification 7 was to fabricate and deliver three Electrostatic Gravity Substitute Workbenches and perform the following tasks: qualification testing; configuration management; preparation of a procedure for operation, maintenance, and handling; end item support requirements definition; and design and fabrication of shipping and storage containers. In addition, engineering support for the Aerodynamic Workbench was included. It was awarded on November 14, 1969 and known as Phase III - Fabrication and Qualification.

e. Modification 8 provided CCSD with certain items of GFP material and was issued January 5, 1970.

f. Modification 9 extended the period of performance from October 15, 1970 to November 18, 1970 and increased estimated cost. It was awarded June 8, 1970.

g. Modification 10 extended the period of performance from November 18, 1970 to December 7, 1970 and was issued on September 2, 1970.

h. Modification 11 extended the period of performance from December 7, 1970 to December 21, 1970.

i. Modification 12 established final G&A rate for CY1968.

j. Modification 13 extended the period of performance from December 21, 1970 to January 31, 1971.

1.1.3 Report Scope

The effort expended under the Phase I - Study scope (paragraph 1.1.2) was documented in the "Final Report - Phase I - Study of An Electrostatic Zero-Gravity Workbench Prototype", dated April 23, 1969; therefore, the Phase I work will not be documented in this report except that the conclusions and recommendations may be mentioned where they relate to the total contract scope. The discussion portion of this report will have three main subdivisions corresponding to Phase II - Design, Phase IIA - Engineering Prototype, and Phase III - Fabrication and Qualification, as outlined in paragraph 1.1.2 c, d and e.

1.2 OBJECT

The object of the work covered by this final report was fourfold:

a. Develop and document a design for an Electrostatic Gravity Substitute Workbench as a safe and useful experiment in Skylab.

b. Develop and document a design for an Aerodynamic Gravity Substitute Workbench as a safe and useful experiment in Skylab.

c. Fabricate and test an engineering prototype of the Electrostatic Workbench as a development tool for the design task.

d. Fabricate and deliver three Electrostatic Workbenches in accordance with the documentation produced in the design phase. One of these units is to be qualification tested.

1.3 CONCLUSIONS

Conclusions based upon the effort described in this report are as follows:

a. The basic power supply design is satisfactory for the intended use. No failures were encountered due to exposure to the environments of the qualification test (as reported in appendix C) as evidenced by the consistent presence of electrostatic voltage at the ion shield cover.

b. Structural integrity of ion shield, support bracket system, and the table top storage provisions was demonstrated during the qualification tests.

c. Safety from the standpoint of injurious electrical shock to the operator has been demonstrated. A mild shock which can be experienced under some conditions is undesirable and would impair the operator's concentration. This can be eliminated by the use of a suitably grounded wrist or ankle strap.

d. Although no attempt has been made to define a "useful force", the relatively small electro-attractive force available would be of benefit to an astronaut in a zero-g environment. In terms of earth gravity, the electroadhesive forces on a machine screw correspond to 1.4g and 0.23 g depending upon orientation and are considered to be significant. See paragraph 2.2.5.

e. Inconsistent and, at times, negligible force measurements were noted during portions of both prototype unit tests and qualification unit tests. Attempts to overcome these conditions appeared to be successful on the prototype unit but other anomalies became evident during the qualification testing. Additional factors are involved in these anomalies which are not completely understood at this time.

1.4 RECOMMENDATIONS

The work accomplished under this contract clearly indicates that electrostatics (and its application to the work station) has some unique advantages in a zero-g environment. However, the incidents and findings reported under paragraph 2.3.5 are evidence that the full potential has not yet been achieved; therefore, CCSD recommends that additional effort be expended as follows:

a. A more rigorous study of the theoretical phenomena leading to the more efficient use of practical materials and configurations.

b. Experimental development and testing of modifications to the present design which would improve both force level and repeatability.

c. Development and demonstration of a comprehensive safety program to cover all known requirements.

d. A preliminary study of other applications of electrostatics in space.

Section 2

DISCUSSION

2.1 INTRODUCTION

This section contains discussions on the Phase II - Design, Phase IIA - Engineering Prototyote and the Phase III Fabrication and Qualification for the electrostatic and aerodynamic workbench for Skylab. Included are discussions on testing, safety, late developments, quality, reliability storage and shipping.

2.2 PHASE II - DESIGN

2.2.1 Theory of Operation

The theory of operation for both the electrostatic and the aerodynamic workbenches is as follows:

a. The electrostatic workbench is composed of a power supply, ion emitter and a work surface at ground potential. The ion emitter, operating at a fairly high potential, generates a cloud of positive ions which are attracted to the work surface. Any object, without particular regard to its material properties, in this field will gain a charge by collecting ions and will also be attracted to the work surface. Once in contact with it, the object will be under the influence of electroadhesive forces. The work surface must be coated with a substance of the proper resistivity, conductive enough to carry charges to the coating surface yet resistive enough to prevent points of ohmic contacts from draining away these charges at too great a rate. If the operator touches a metallic object, the charges will be drained and adhesion is lost. Therefore, it is desirable to maintain the conductive part of the work surface at a -300 volt potential.

b. The aerodynamic workbench consists of an electric motor and fan combination, operating in the throat of a venturi, which draws the workshop atmosphere through a screened working surface. The passage of the atmosphere over an object restrained by the screen will create aerodynamic drag, thus developing a useful force.

2.2.2 General Considerations

The design phase was initiated with a good portion taking place during a period of change and uncertainty in the overall design criteria. A decision which helped to ease the design task was made by the M507 Principal Investigator in April of 1968, to change the workbench working surfaces from oval shape to circular. A second problem of major importance was that initial planning was based on the "wet" workshop concept wherein permanently installed portions of the workbenches would be exposed to an LN_2 environment while the removable subassemblies would be stowed in containers in the MDA (Multiple Docking Adaptor). Although there were some indications that the "dry" Workshop might become a reality, the preliminary design had to consider both possibilities until July 28, 1969 when the change became official. The environmental design criteria were in a state of uncertainty and it was November 1969 before Chrysler received any criteria, and this was in the form of an unofficial copy of IN-ASTN-AD-70-1, "Preliminary Vibration, Accoustic, and Shock Specifications for Components on Saturn V Workshop".

This meant that stress assumptions had to be made to maintain documentation schedules with the risk that later analysis and/or test would show marginal strength.

2.2.3 Electrostatic Workbench

2.2.3.1 Preliminary Design

The documentation for this milestone took the form of partial layouts, sketches, reports, and notes. With the realization that changing interface requirements would require revisions, informal approval was given by the Principal Investigator on July 24, 1969 for the general concept. Other items of preliminary design were decided upon during subsequent months.

2.2.3.1.1 General Configuration. The original concept considered a power supply built into the ion source and shield. This concept proved impractical when it was established that both the size and weight of the supply would have to increase considerably over the early estimate. Additionally, the voltage selector switch would be in an inconvenient location. A second concept mounted the power supply to the working surface at its back edge where it served as the base for the bent conduit support for the ion source in the manner of a street light. During the "wet" OWS period, many other schemes were sketched to provide quick mechanical disconnect with the OWS tank wall and yet to fit within an MDA storage container of minimum size. These concepts were discarded in favor of a simple, cantilever support from the compartment wall when the "dry" OWS became a reality.

Concern over the as yet unspecified shock and vibration requirements led Chrysler to consider several approaches to a hinged ion source bracket which would allow the source and shield to be folded against the wall during liftoff and boost. These proved to be more complex and heavier than a more rugged cantilever concept without that feature.

2.2.3.1.2 Work Surface. A specific recommendation was made in the Phase I report to use porcelain-coated steel for the electroadhesive surface. Although this selection had the obvious advantages of non-flammability, non-toxity, cleanability and good wear resistance, serious doubts arose from a practical engineering point of view. Porcelainizing is a very common commercial process but most fabricators were not equipped or interested in special, small quantity work. The steel used is of a special grade; also a certain minimum thickness is needed to reduce warping. The "frit" composition and resulting coating thickness are not closely controlled, thus the effects of these two factors on electroadhesiveness were unknown. A piece of the recommended material 2 feet in diameter would weigh about 7 pounds which is a large percentage of the 12-pound total workbench weight goal. In search for a lighter weight construction that would still maintain flatness, thinner sheets of steel, titanium, and aluminum were considered with reinforcing ribs or sandwich make-up. The fabrication of these combinations appeared to be rather difficult. One processor agreed to furnish small experimental samples of several thicknesses of porcelain on aluminum and titanium. However, process control of these samples was difficult and the smoothness, flatness, and thickness uniformity was less than desired.

It occurred to Chrysler that hard-coat anodized aluminum might also be a good electroadhesive material. A sample was processed and tested by the simple -300-volt bias method (see figure 1); the sample produced forces greater than those previously obtained with porcelain/steel.

Comparative testing was conducted on these candidates with the following results:

Sample Composition	Avg. Force (grams)
Porcelain/titanium	30
Porcelain/steel (0.007 inch coating)	3
Porcelain/steel (0.005 inch coating)	1
Porcelain/steel (0.003 inch coating)	4
Porcelain/aluminum (3M Co. No. HT)	12
Hard coat anodize/aluminum (0.002 inch)	56

These values represent the average of several readings taken at several locations on each sample. However, fairly high dispersion was noted, due in part to local surface imperfections and instrumentation error. From these results it was decided to try two materials for engineering prototype evaluation: the porcelainized steel, because of its high recommendation in Phase I, and hard coat anodized aluminum because of its apparent superiority.

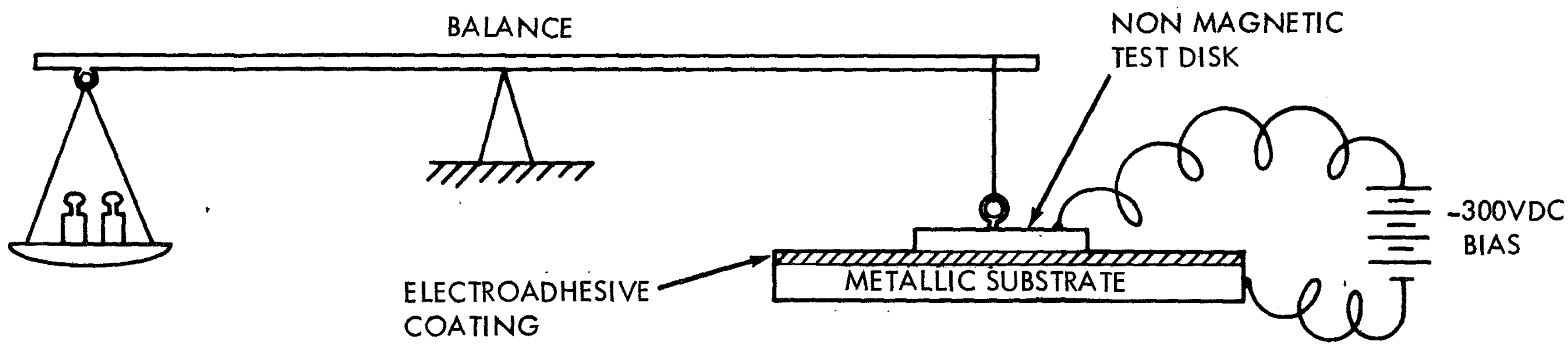


Figure 1. Electroadhesive Measurement - Bias Method

2.2.3.1.3 Ion Source and Shield. The design criteria of the Phase I Study specified that the ion source was to be a stainless steel needle point. This appeared to be a good choice and preliminary design effort was not expended to investigate alternate materials or configurations. The shield to enclose the ion source was to be the work surface shape (i.e., round), and was to focus the ion beam at the work surface 18 inches away. Maintaining the depth/breadth ratio used in the study, the shield automatically became the frustrum of a cone with a base diameter of 8 inches. The bottom, or protective cover, was to be perforated with 1/8-inch holes on 1/2-inch centers. Holes were required for ion egress and the 1/8-inch size seemed to be the largest commensurate with safety (guarding against the deliberate or inadvertent entrance of foreign objects to the proximity of the high voltage source).

The major problem at this point in the design was the selection of material which must be a good insulator, reasonably rugged, and acceptable from the standpoint of flammability and outgassing. Test results for candidate ATM material applications were made available to Chrysler, but a specific recommendation for our application was not forthcoming from the MSFC Materials Laboratory because this laboratory concerns itself with the evaluation of materials submitted to them as candidates for a particular application, rather than recommending a specific material for a specific application. The choice narrowed down to Teflon (TFE) and polyimide. Only a few manufacturers make these materials and some of them are not fabricators. Neither of these materials is easily bonded and the use of metallic fasteners to build up this complex shape was undesirable, considering the proximity of the ion source. Many inquiries were made to possible vendors but with limited success. One fabricator, who also produced the raw material, agreed to furnish a one-piece shield cone of Teflon having a 1/8-inch wall thickness and a perforated cover.

The preliminary design concept was further developed for clamping the ion needle and its high voltage cable to the shield by bonding and nylon screws.

2.2.3.1.4 Ion Source Support and Bracket. The ion source was planned to be centered over the working surface at a point about 15 inches from the Skylab wall. The support for the source and shield was required to be non-metallic and rigid. Inquiries were sent out and a West Coast fabricator recommended a hollow tube of laminated fiberglass impregnated with polyimide. The attaching bracket which would interface with the Skylab wall could safely be metallic and was sketched as a welded assembly with mounting holes to match the standard Apollo grid pattern.

2.2.3.1.5 Power Supply. The basic requirements for the power supply were: a -300 vdc bias section and a high voltage section, switchable to nominal values of 10KV, 20KV, 30KV, and 40KV; very low power; small size and light weight; and capable of operating in the Skylab environment. A thorough search was conducted without success for an available unit, or even a portion that could be utilized. One manufacturer offered to design and build such a supply but for a price and to a schedule far beyond the limitations of our contract.

Preliminary design of the circuits began and a breadboard of a candidate voltage multiplier was built and tested in successive stages. The high-voltage small-size diodes needed for this diode-capacitor ladder type design were available from only one vendor. The remainder of the power supply circuit selected is described as follows: A nominal 28-vdc is applied to a four transistor bridge oscillator which is controlled by a saturating transformer and produces a 20Hz, 28-volt peak, square wave. This output is applied to the 300-volt transformer whose output is rectified and filtered to provide the -300 vdc bias to the work surface. The square wave is also applied to the switchable taps of a 2000-volt transformer which in turn feeds the multiplier. The electrical schematic for the power supply in its final form is shown in figure 2.

Concurrent with the circuit design, a number of possible packaging concepts were considered. A two-deck, circular configuration offered several advantages such as compactness and short internal lead lengths. However, it is best suited to a very mature design after a long development period. The two-deck circular configuration is relatively inflexible to development changes because problems occur with connector and pigtail attachment when using the welded lead technique (which would be normal for this configuration); also it would be difficult to take full advantage of volumetric efficiency because of the dissimilar shapes and sizes of components. Hermetically sealed, oil bath construction was also considered, but the factors of facility requirements, cost, and development time were not in its favor.

Although it was likely to result in a somewhat larger size and greater weight, the decision was made to concentrate on a printed circuit board, soldered component, and completely potted design within a metallic case. Also, decided at the outset was that cable connections would be minimized and the high voltage cable would be a pigtail from the power supply, terminating by permanent attachment to the ion source needle. The working surface (table top) was planned to have a single-conductor cable pigtail to mate with a small connector mounted on the power supply case. This connector would not be disconnected after prelaunch checkout but would provide the means for troubleshooting, table top replacement, and would facilitate handling before prelaunch checkout. The initial workshop interface was required to be a zero-g connector, mating with a wall mounted receptacle for 28-vdc supply. This was later changed to a power supply pigtail and conventional connector, mating with a receptacle on the aerodynamic workbench motor control box.

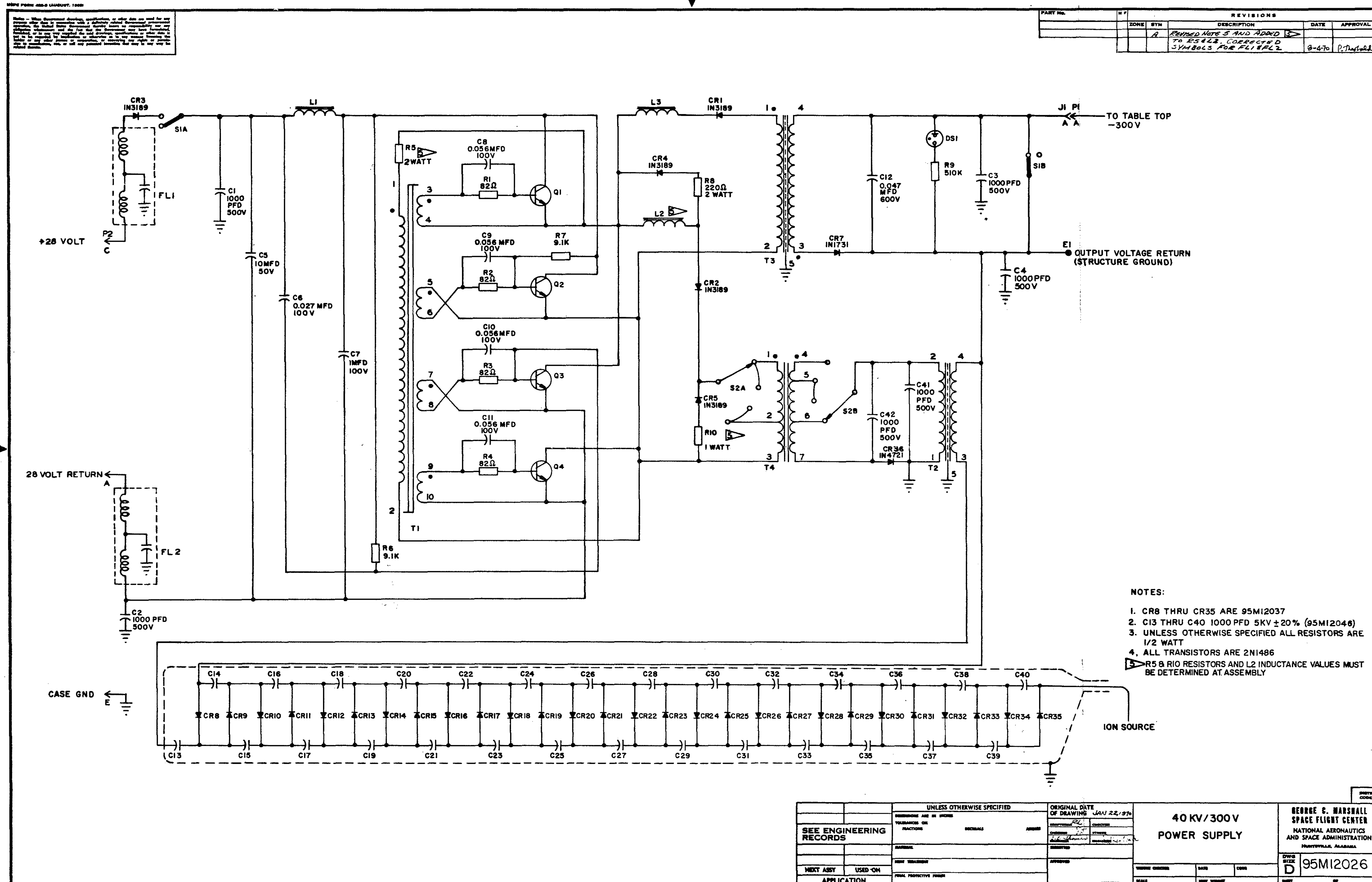


Figure 2. Electrical Schematic

The voltage multiplier was visualized as two parallel printed circuit boards with the high voltage diodes and capacitors in between. This subassembly was to be encased with potting compound. The choice of compound was based upon: high dielectric strength, low shrinkage, low thermal coefficient of expansion, good wetability, and the best possible out-gassing and flammability characteristics. Emerson and Cuming 2850GT, an alumina filled epoxy, appeared to possess the best combination of properties, although it is very viscous, which makes it difficult to deaerate and pour. These properties were also a good match for the epoxy body of the high voltage diode selection.

Requirements for the high voltage cable were: operation at 40kv (but at low power) in an oxygen-rich 5 psi atmosphere, non-flammability, and non-toxic. Even the recognized leaders in the cable industry could not agree on a construction they were confident could meet these requirements. Generally, high voltage cables are custom-built, which results in long lead time and high cost. Our immediate problem for development needs had to be solved in a make-shift manner, using production-run surplus samples of questionable quality and marginal capacity. An additional important consideration was that, although Teflon (TFE) was about the best available material for wire insulation in space, no cable samples had yet passed the rigorous testing for flammability and outgassing by the MSFC-Materials Lab. Variations of an additional outer convoluted jacket were showing some promise, but none had been approved at that time.

Development of the high voltage module (voltage multiplier) became a difficult problem of integrating materials, processes, and components. As mentioned previously, the only available diodes were small and fragile (0.06 inches square by 0.125 inches long with 0.010 silver leads). The assembly is shown in figure 3. Early experiments in potting resulted not only in high voltage leakage but in degraded performance traceable to diode failure. More stringent cleaning techniques were developed, longer leakage paths were provided, and the potting operation was separated into two steps to ease the thermal stress exposure during the exotherm and curing cycles. At one point, it appeared the diodes were being crushed by the very hard and dense potting material. Tests were conducted on sample assemblies using both elevated and room temperature cure epoxies and polyurethane compound. It was concluded that the 2850 GT (160°F cure) compound was still the best choice. After consistent results had been obtained, the required module shielding was added which had the effect of increasing the electrical stress on the potting compound and the power consumption. An outer covering of 1/4-inch plexiglas with the shield external to it was found to be effective. Copper screen had previously been considered for the shield; however, with the selection of plexiglas, an adhesive-backed copper tape with soldered joints was used and a tapered extension was added to the molded contour along the imbedded high voltage cable to decrease the electrical stress concentration and increase the mechanical bonding area. This configuration is shown in figure 4. Until this last modification, potting molds of plexiglas had been used with a high rate of mold attrition. A switch to an aluminum mold was considered feasible at this point.

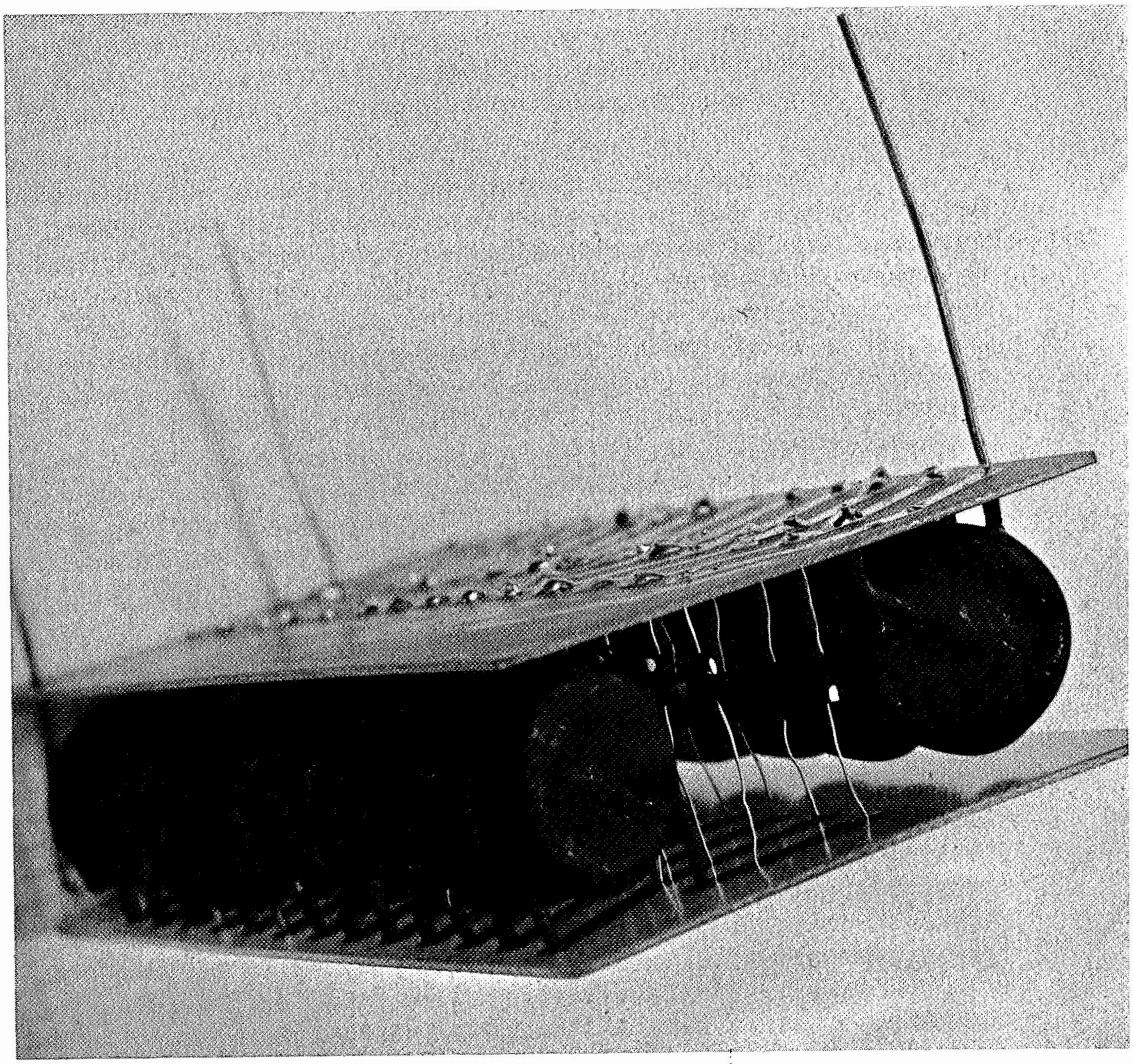


Figure 3. Voltage Multiplier Prior to Potting

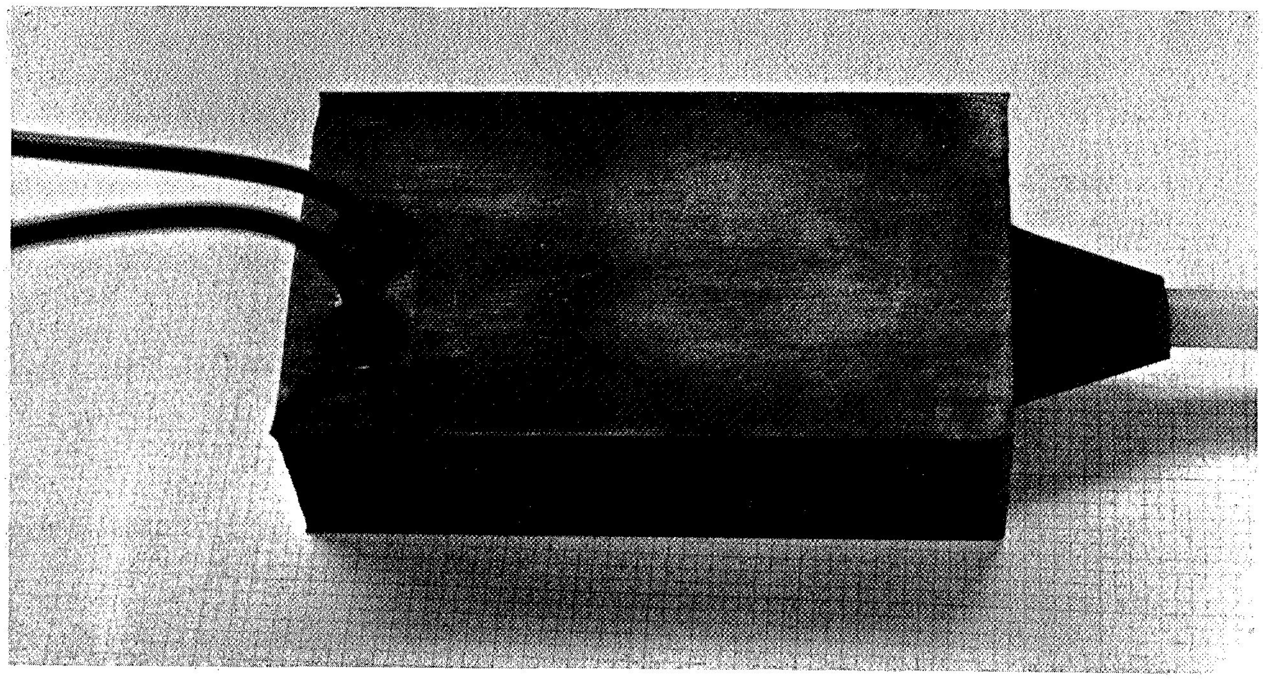


Figure 4. High Voltage Module as Modified

The concept of the low voltage section assembly (containing most of the power supply electronics outside of the high voltage module) underwent very little change. Two printed circuit boards were positioned vertically and parallel, with transformers strung on a rod between them. The voltage selector switch was nested between the boards. Initially, the voltage selector was planned to serve as the power supply ON-OFF switch. However, reliable startup of the oscillator with low input voltage could only be guaranteed by use of a separate ON-OFF switch.

The Phase I-Study recommended the inclusion of a 300-megohm resistor in the high voltage circuit as a safety measure. During the preliminary design and breadboarding of the circuit, it was determined that this feature would result in considerable weight and power penalties. Instead, a highly dependable current-limiting circuit that would reduce the output voltage immediately in the presence of a low resistance condition was incorporated. The current limiting ability of this circuit design is illustrated in figure 5.

2.2.3.1.6 Table Top Storage. After the dry workshop decision was made, it was planned to stow the table top in a pocket attached to the wall at the right side of the power supply and close to the floor where it would remain with its 300-volt cable attached at all times when not in actual use. Several location reassignments were made and finally the table was moved to the left and some distance from the floor. Three mounting brackets, designed for easy operation, were then used.

2.2.3.2 Formal Design

The formal design to which the three units of the final contract phase were to be fabricated was to be documented in drawings, parts lists, and specifications. The documentation was to reflect the results of the preliminary design and incorporate any changes found to be necessary or desirable by the building and testing of an engineering prototype unit.

It should be noted that no particular date or event marked the transition from preliminary to formal design. Some changes (particularly those affecting the interface of M507 to the workshop) were made prior to formal documentation, some during the formal activity on a particular part or assembly, and others after drawing completion and release. In the latter case, the change became a drawing revision.

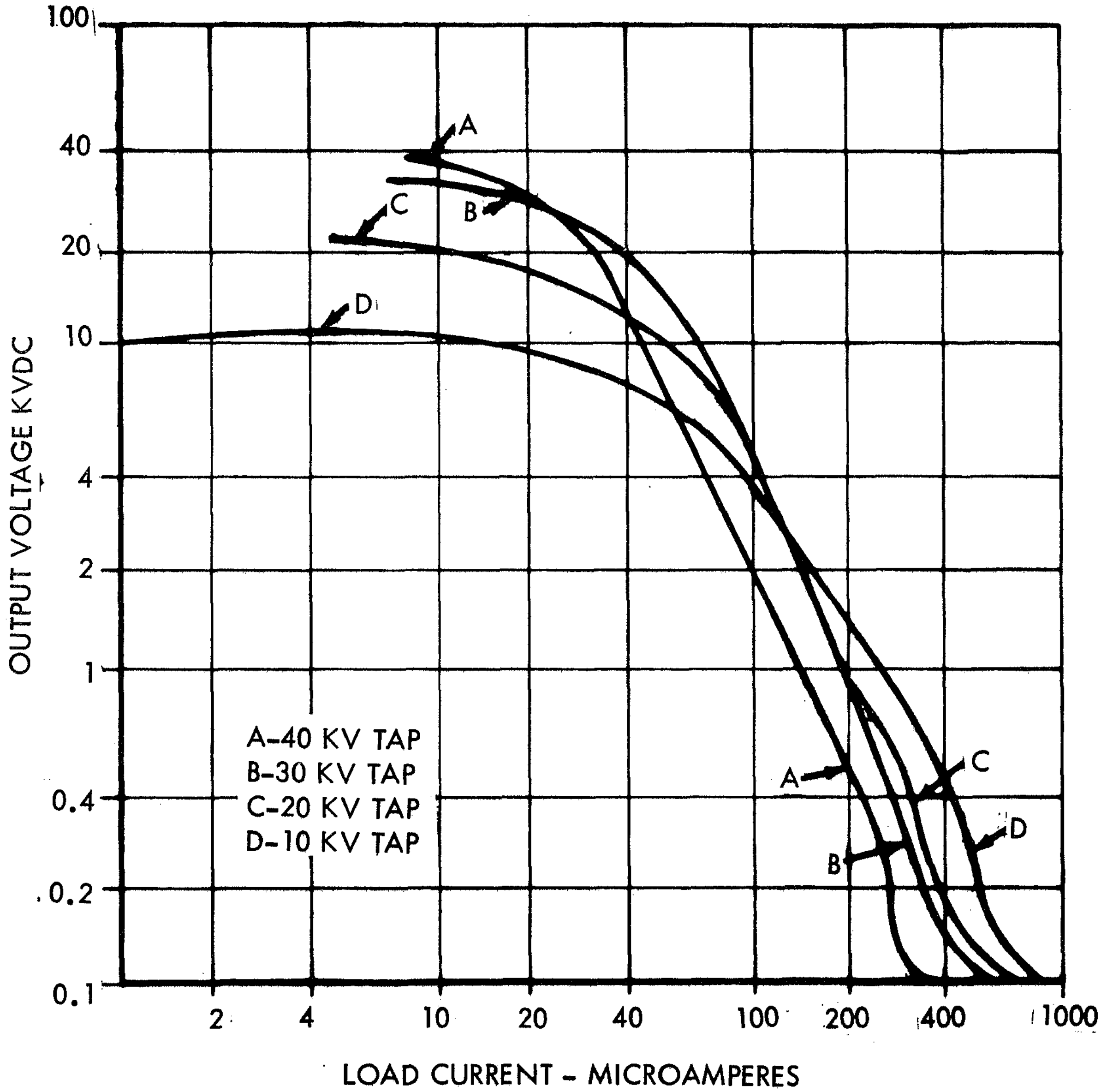


Figure 5. High-Voltage Output Volt-Ampere Characteristics

2.2.3.2.1 General Configuration. The arrangement of the electrostatic workbench elements as shown in figure 6 was the result of human engineering considerations, Skylab interface requirements, and interaction with the aerodynamic workbench. The purpose of the M507 to serve as a work station established the location for the work surface and the use of one structure for both methods of gravity substitution was both logical and economical. The ion source and shield enclosure being 18 inches above the table allows ample working clearance and is situated like a light fixture over a normal 1g workbench. The power supply and its controls are located for convenient access and observation by the operator when he is standing in front of or to the right of the work surface. Location of the table top storage to the left was dictated by a reassignment of space in the Skylab. Elimination of connectors involving the operator not only reduces the things he has to do to activate and use the facility but adds to workbench reliability. This design is defined by MSFC drawing and Parts List No. 95M12015. Descriptions of the component parts are as follows:

a) External Cables. There are three external cables in this system; high voltage, table top and 28-volt input cable. As previously stated, no cables passed the flammability and outgassing tests. This problem was resolved when Chrysler completed their formal design specification for the high voltage cable and submitted it for approval. It called for a shielded single conductor construction with teflon primary insulation and outer jacket. Approval was given to the specification provided the cable was encased in a convoluted tubing having a woven fiberglass inner sheath. This type of protection had just been successfully tested. The necessary changes to the formal documentation were made to accommodate the tubing and end fittings for all three cable applications.

b) Work Surface. The work surface or table top is a 24-inch diameter aluminum alloy plate, 1/4-inch thick with the bottom side milled to leave a stiffening rib pattern and a minimum weight. The entire outside surface is given a hard coat anodize finish with the exception of a small electrical contact area which is treated with alodine. A single teflon insulated wire for the 300-vdc table bias is attached to the table with a terminal lug, forming a 3 1/2-foot pigtail which terminates in a 40M39569 connector plug. Icore convolute tubing and end fittings protect the complete cable. The table top terminal is further protected by a teflon block and cap, designed as a convenient handle to move the table in and out of the operating position. Additional insulation protection and centering within the upper rim of the aerodynamic workbench is provided by three teflon spacers about the table's rim.

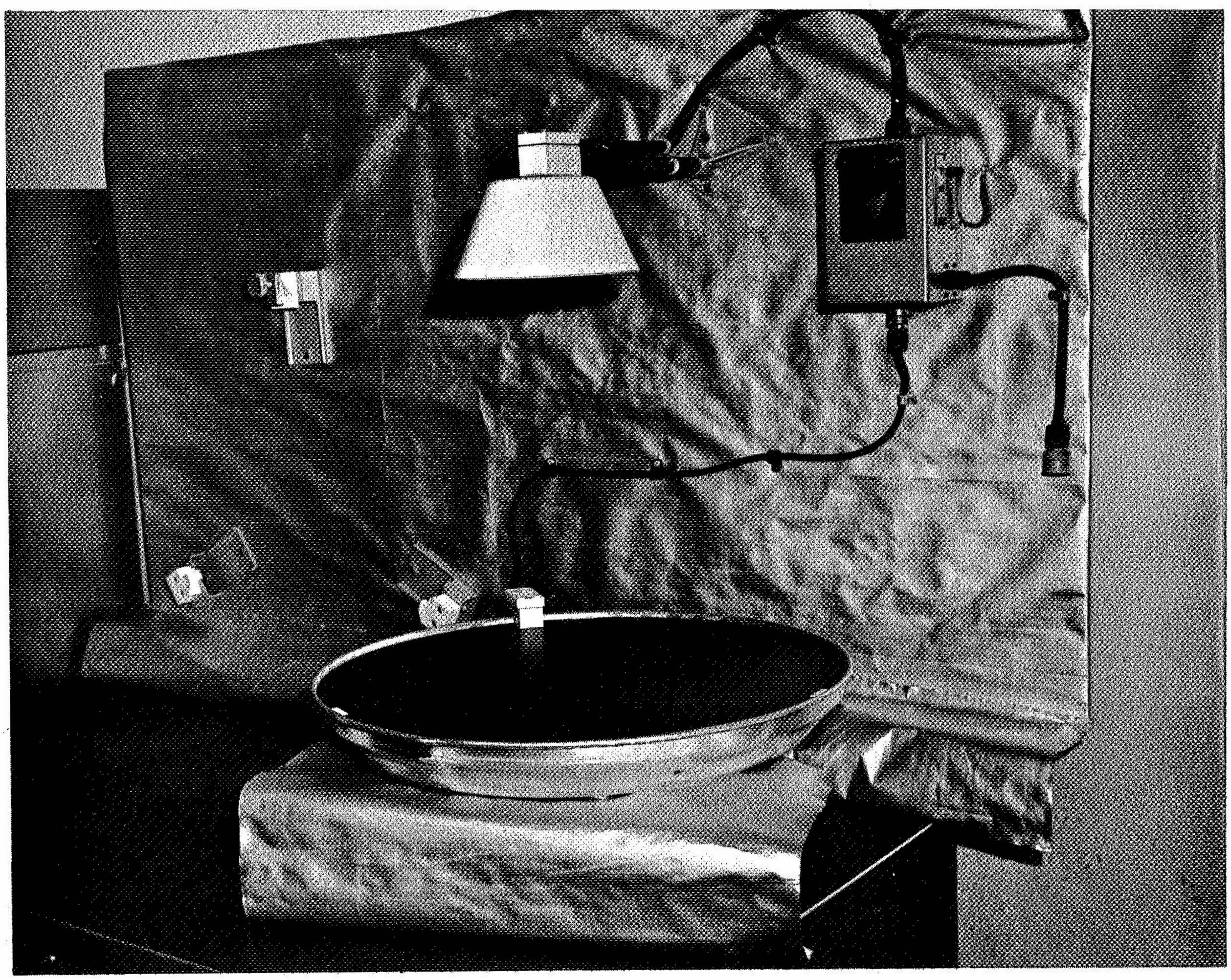


Figure 6. Electrostatic Workbench Operational Condition

c) Ion Source Shield. The contour of the shield and the nominal 1/8-inch teflon wall have not changed since early concept. Its shape is the frustrum of a cone, having a major diameter of 8 inches, a minor diameter of 4 1/2 inches, and a height of 4 inches (see figure 6.) An integral boss projects inward from the small end to protect and support the ion emitter shank. A block of teflon into which the support is sunk and doweled, is attached to the shield by 3 nylon screws and epoxy adhesive. The teflon cap is attached to the block with 4 nylon screws, firmly clamping the high voltage cable, and sealing off the emitter/ conductor junction. An 8-inch diameter cover completes the shield enclosure and is perforated by 1/8-inch holes on 1/2-inch centers.

After release of the formal documentation, the following major changes were made:

1) The internal boss was shortened to correspond to the latest prototype configuration.

2) The perforated cover was made into a sandwich by bonding a copper foil bleed pattern to its outer surface and then bonding a 0.010-inch teflon sheet overall.

3) A hole was added in the small end of the shield adjacent to the support so that the bleed pattern cable could leave the shield interior and pass into the hollow support.

4) The block and cap were modified so as to clamp the end of the convolute tubing.

d) Support and Bracket. The support is a hollow tube of polyimide resin fiberglass laminate with a 1/2-inch inside diameter and a 1/8-inch wall. (See figure 6.) Its length suspends the ion emitter 15 inches from the wall. Both ends are specified as a close fit with the mating holes in the shield block where a teflon dowel is fitted on assembly and also in the bracket where two spring pins are fitted on assembly. The only change after release was to add a slot opposite the bleed cable hole in the shield.

The bracket is a welded aluminum part which provides a rigid socket for the support and the interface with the Skylab wall. The first design (and the one used for the prototype) used a 3-hole mounting pattern to match the standard Apollo grid. The Integration Contractor reoriented this grid pattern, which necessitated a redesign to a 4-hole mounting.

Subsequent to release, the interface was specified to be electrically conductive; therefore, the faying surface was changed from anodize to alodine. With the advent of the bleed provision, an additional hole was made through the bracket hub and support for lead egress and one of the ribs was modified to receive the ground connection.

e) Ion Bleed Circuit. This provision was not part of the final documentation at the time of release. Its purpose and function is explained under paragraph 2.3.3. The 10k megohms bleed resistor has a length of high voltage cable crimped to one lead and a length of insulated hook-up wire crimped to the other. The resistor and two crimped lengths are potted with 2850 GT in a cylindrical mold. This subassembly is placed into the support tube with the high voltage pigtail feeding through the new shield hole and cemented to the inside of the shield to emerge through the cover where it is soldered to the bleed pattern foil. The other pigtail is fed through the new hole at the bracket, a terminal lug is attached and is grounded to the bracket rib. The potted resistor is cemented to the inside of the support tube.

f) Power Supply (Electronic Assembly). All of the power supply electronics are potted within a formed and welded aluminum case. (See figures 7 and 8.) The base plate is assembled to the case before curing the last potting step; this effectively excludes the environments (humidity, vacuum, etc.) to which it would be exposed. Two convolute tubing protected pigtails emerge from the case. The high voltage cable is located at the top and has the ion emitter silver soldered to the end of the conductor that has its shield stripped back to a point where the installed cable leaves the grid wall. The ion emitter is made from 1/8-inch stainless steel rod tapered to a point over a 1/2-inch length. The second pigtail contains three individual insulated wires that make up the 28-vdc input power. This pigtail is attached to the right side of the case and terminates in a 40M39569 connector. A bulkhead receptacle is installed in the bottom wall of the case for connection to the table top. A power return jumper is attached to an insulated stud, also located on the right side of the case, and must be bonded electrically to the wall grid structure. The entire exterior of the case and base is finished with alodine. The controls for the power supply consist of an ON-OFF toggle switch, a VOLTAGE ON neon pilot light, and a 4-position VOLTAGE SELECTOR switch.

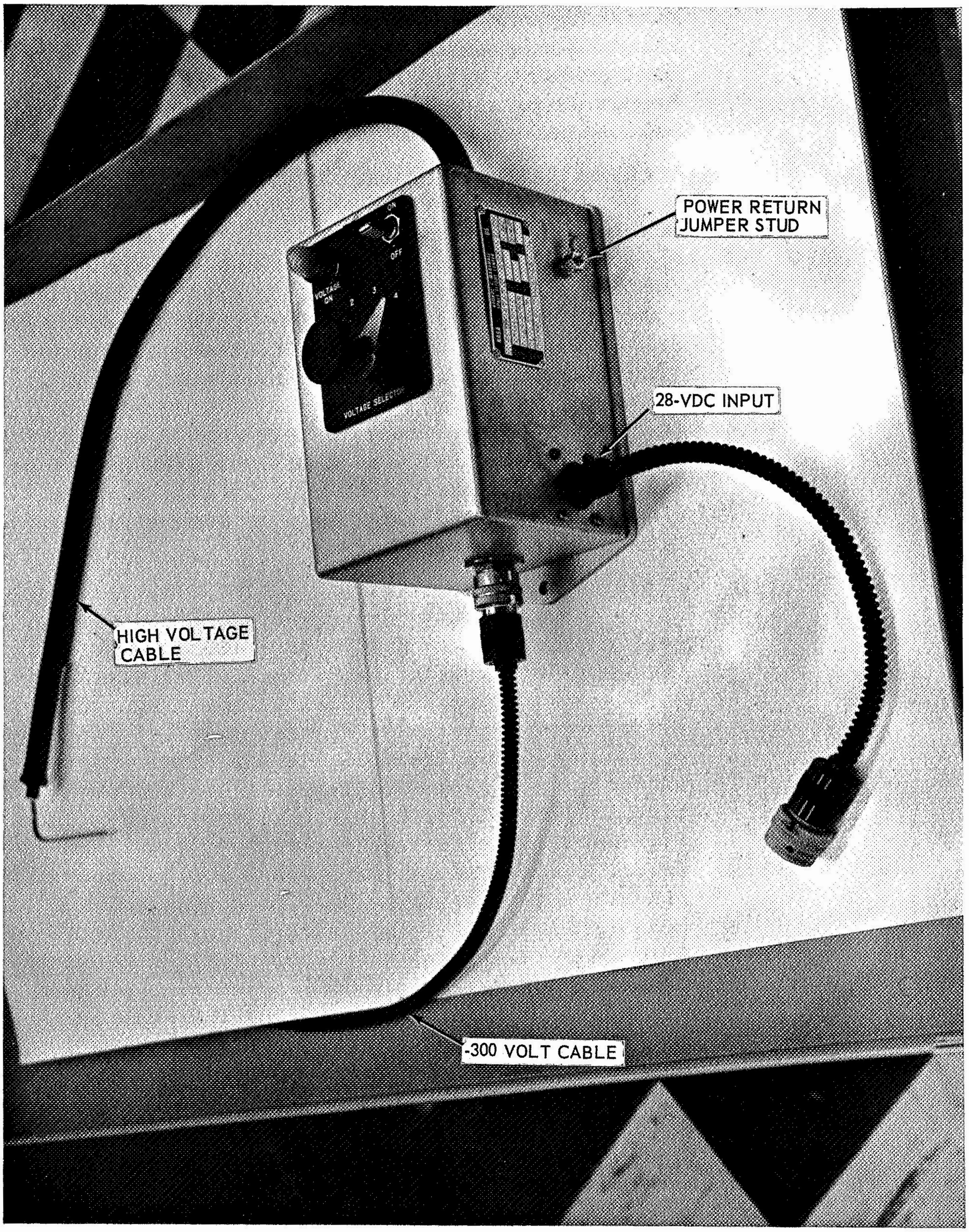


Figure 7. Electronic Assembly

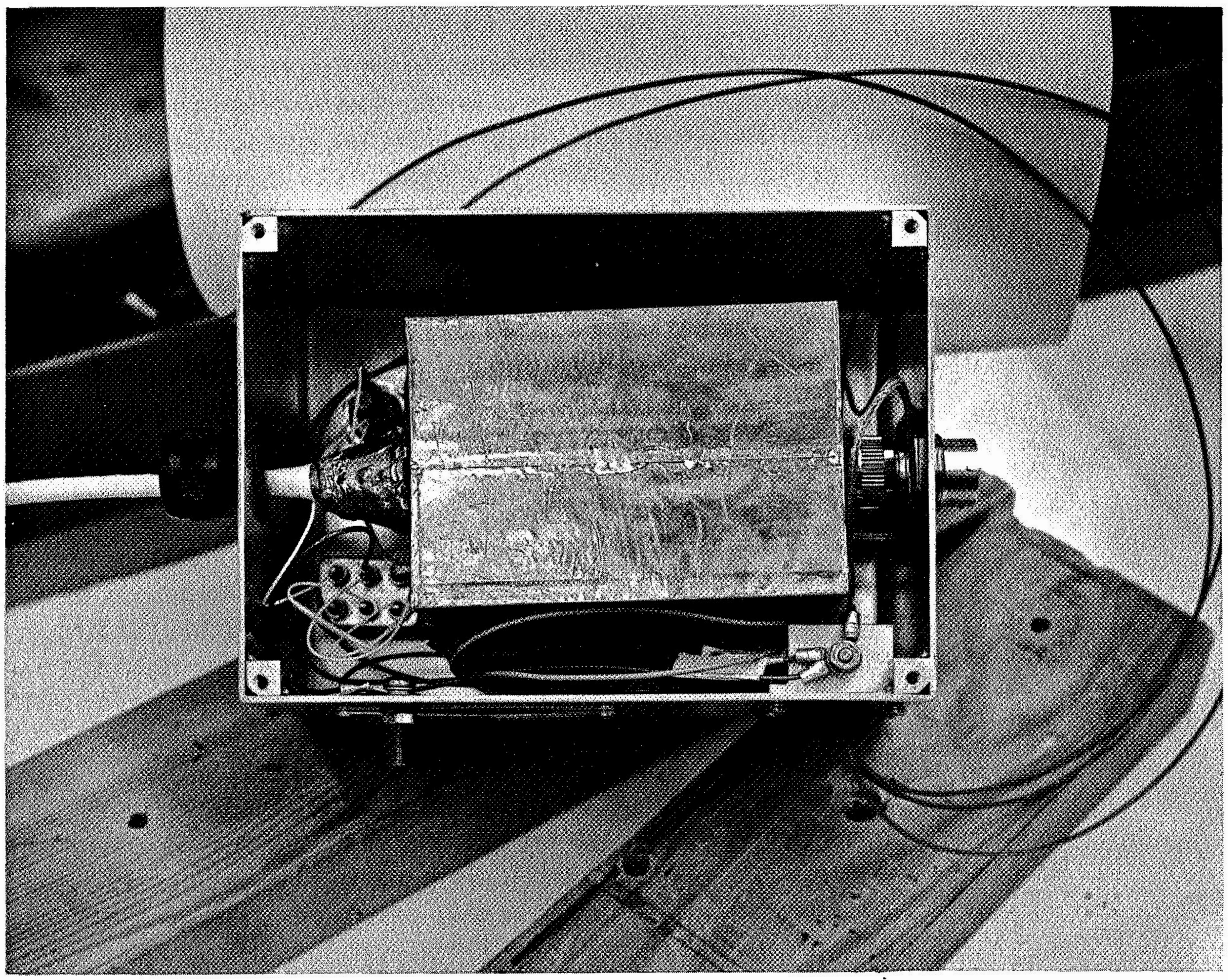


Figure 8. Electronic Assembly Prior to Potting

Functions are clearly identified by an engraved, black anodized plate. The voltage selector switch positions are marked 1, 2, 3, and 4 which correspond approximately to voltage outputs of 10, 20, 30, and 40kv, respectively.

The internal construction has been partially described under the preliminary design discussion (paragraph 2.2.3.1). The high voltage module is located adjacent to the base (see figure 8), with the two input terminals located on its opposite face. A split tapered bushing of teflon is assembled around the high voltage cable and, when wedged into the convolute tubing adapter fitting, helps to locate the module during potting. The module shield is attached by braid to the "Case Ground Stud." As additional assurance against thermal and other stresses, the high voltage diode body was increased to 0.1 by 0.1 by 0.4 inches without changing the internal configuration.

For the qualification unit, the low voltage assembly was prepotted in a separate mold to encase all of the wiring and make the selector switch a part of this subassembly. Sealing the mold from leakage and controlling the exit of interconnecting pigtails was found to be too difficult. The documentation was revised to call for installation within the case, connection with switches, pilot light, etc. and potting in place with Emerson-Cuming No. 1090 SI to the same level as previously intended. The assembly just prior to potting is shown in figure 8. After the first potting operation the last connections are then completed, the high voltage module nested between the low voltage board ends, and a second potting operation is performed to within 1/8-inch of the case lip. A topping layer of No. 2850 GT completes the pouring and the base is assembled before curing. During preparation of the case for potting, the filter compartment is installed with two input line filters and the case ground stud in place. The cavity of this compartment is accessible from outside the case and filled with compound.

g) <u>Electronic Component Selection.</u> The components used for the breadboard during the preliminary design were chosen primarily for their functional suitability and availability while reliability was of secondary concern. When the circuit was satisfactorily established and preliminary packaging planned, a decision had to be made regarding the final design component selection. Factors to be weighed were: reliability requirements, size, compatibility with packaging environment, method of electrical interconnection, cost, and delivery. It had been established that the experiment would not be considered more severly than Criticality Category 3 and that funding could not support a full-fledged quality assurance and reliability program. Time schedules were critical; consequently, trade-off selections had to be made which ruled out specifying high reliability and screened types. For example, MIL-R-39008 resistors were selected in preference to MIL-R-39017 types, JAN1N5199 diodes in place of S1N5199, and MIL-C-25 capacitors in place of the 50M60180 type. Because of the critical nature of the high voltage diodes, a degree of screening was specified for this one type component.

h) Table Top Storage. The three storage brackets utilize identically formed aluminum bases. Two of the brackets are non-adjustable and include teflon blocks with tapered notches to secure the table rim. The third bracket is adjustable by means of a knob and finger arrangement. With the knob loosened and the finger rotated out of the way, the table rim is located first in the notches of the two non-adjustable brackets, then rotated into the adjustable bracket against its teflon pad. The finger is swung around to contact the back of the table and the knob tightened. The working surface is then facing the grid wall and protected from direct impact of floating debris.

2.2.4 Aerodynamic Workbench

2.2.4.1 Preliminary Design

This design task was conducted entirely different from that for the electrostatic workbench. MSFC-ME was to handle all work involving hardware and testing, while CCSD's responsibility was to propose design concepts and to document the formal design. The electric motors, impellers, and speed controls had been specified and procured, and the intention was to use them for flight hardware with or without further modifications. The Principal Investigator felt the need to build a mock-up and to initiate some preliminary testing of the motor-fan combination at the earliest possible date. This had the effect of curtailing the preliminary design period and of expediting at least portions of the formal design effort.

a) General Configuration. The original concept as proposed in the Nortronics Phase I Report was a working surface comprising a wall-mounted venturi with an oval-shaped entrance covered with a screen. The motor driven fan would draw the workshop atmosphere through the screen and exhaust it in the direction of the floor grid. The screen, backed by an egg crate structure, would also support the electrostatic table top during that part of the experiment. However, early in 1969, it was decided to change the oval shape working surface to circular, thus simplifying the design and reducing the cost of fabrication.

Prior to the dry workshop decision, the venturi was planned to be permanently mounted and the motor, fan, and controls to be easily removable for storage in the MDA container. Some study and sketching was done in search of the best practical way to accomplish this, which would also require that the working surface be hinged or removable.

The Experiment Integration Plan included the use of a chronometer and a grid as a background for motion picture recording. Certain objects were to be released above the working surface and their time/motion behavior noted as they contacted the table. Early in the preliminary design period the requirement for the chronometer and grid was dropped in favor of the gross indication offered by the grid pattern on the wall.

b) Venturi. A sheet metal spinning capability existed at MSFC and could be utilized now that the shape was cylindrical. Based to some extent on the Phase I Study, CCSD and MSFC established a venturi contour and upper rim configuration (24-inch entrance diameter and a throat to clear the 18-inch diameter fan). The entrance and exit contours were to be identical except that the throats would be enough different to permit the upper to fit within the lower, thereby resulting in an overall length of 23-1/2 inches. These shapes were spun quite easily, and with very little added effort enough shells were made for the total anticipated requirement. Thus, the preliminary design became the final design. A reinforcing band was added around the throat area. The upper rim was planned to attach to the venturi entrance and form a cavity for the aerodynamic table surface. In addition, the rim height was great enough to contain the electrostatic table top (stacked on top of the screen in operational position) and still furnish a boundary for any object having a tendency to roll off the table.

c) Table Assembly. It was previously agreed that the contact surface would be stainless steel screen with a sufficiently dense mesh to prevent small screws and hardware parts from passing through. The problem was to provide a screen support to negate sagging without seriously affecting the airflow. Where a search failed to reveal the availability of a suitable configuration of acceptable material, Chrysler studied three or four alternate constructions. These involved various formed sheet metal shapes and assembly by rivets or welding. All appeared costly for the quantities required and all suffered complications in terminating a repetitive pattern in a 24-inch diameter. Looking for a mock-up substitute, the Principal Investigator chose a section of the standard Apollo grid, had it cut to a circular shape and welded a 1/8 inch aluminum ring about its periphery. A larger ring was constructed and, with the screen laid across the grid, this ring was pressed on. Not only was the screen retained but tension could be developed to minimize looseness and waviness. This became the preliminary design.

d) Venturi Supports and Brackets. Although several other approaches were briefly considered, the strut type of support was chosen for its light weight. Right and left hand strut assemblies were to be composed of two aluminum tubes with three welded end fittings. One end of the horizontal tube would attach to a hat-shaped bracket at the venturi reinforcing band and the diagonal member would be welded to the same fitting and extend to a wall bracket at about working surface level. Stability was provided by a rear strut assembly of similar construction which attached at its central fitting to the rear of the reinforcing band and fastened to the two wall brackets already serving the side struts. Final suspension stability was assured by a wall bracket attached to an upper rim hat bracket with a single bolt. Thus, the entire venturi could be removed by detaching four bolts. The wall mounting brackets were designed to pick up a single bolt attachment to the strut end fittings and to interface with mounting pads on the S-IVB tank wall. When the assigned location of M507 was switched to a compartment wall, the bracket design was changed to provide a 3-hole grouping to match the standard Apollo grid wall. Bracket construction was welded aluminum, followed by machining and anodize treatment.

e) D. C. Motor and Motor Control Box. As mentioned previously, quantities of these two assemblies had already been delivered to MSFC by the time the design phase began. They were produced by the EEMCO Division of Electronics Specialty Co. Chrysler's only design responsibility for these two items was to incorporate the furnished EEMCO documentation into the drawing set.

f) Motor Support. Early design effort was concerned with the astronaut's problem of installing and removing the motor-fan combination with minimum effort and risk of misassembly. A ring, attached to the motor with struts sliding into the throat area to a shoulder and retained by detents or a mechanical lock, appeared to be the best solution. When the in-flight assembly requirement was deleted, efforts were redirected towards a strut and throat-mounted bracket combination that would offer minimum aerodynamic drag and least cost to fabricate. However, the specified fan had four blades and the motor, four equally spaced mounting angles which could lead to severe noise, vibration, and flow irregularity problems. Testing of the mock-up revealed that the fan speeds necessary to produce the required flow were sufficiently low so that this problem did not materialize. A simple flat plate design was sketched for the struts and a non-streamlined attachment bracket documented for the mock-up.

g) Electrostatic Table Retention. Trade-off studies were made to determine whether the principal parts should be on the table or upper rim of the venturi. It was more practical to keep the table surface uncluttered and as uncomplicated as possible because the table must be handled in and out of the storage brackets and the installed position. Many mechanisms were examined from the standpoint that the astronaut would be holding the table by the cap/block handle with one hand and the other available to secure it in position. Ease of insertion and removal, reliability of retention, and low cost were additional considerations. Sliding mechanical bolts, threaded fittings, spring loaded latches, and cams were considered. Two factors were of major importance: wide tolerances of the sheet metal rim on diameter and roundness, and the vertical stack-up of the aerodynamic table in the rim, its thickness, and the effective thickness of the electrostatic table. The analysis favored a three-point retention and a thumb wheel actuated bolt mechanism. The bolt tip would be of teflon and cut at an angle to contact the top edge of the table rim, and wedge it down.

2.2.4.2 Formal Design

The Aerodynamic Workbench mock-up built by MSFC was updated to a prototype configuration. Some of the interim measures taken in building the mock-up have proved to be adequate and, for economic reasons, were translated into the formal design.

a) General Configuration. The venturi and the table is suspended from the wall to form a work station approximately 42 inches from the floor. The motor control is wall mounted about 18 inches to the right of the venturi and a few inches above the 24-inch diameter work surface for convenient access and viewing. The only cable in this system extends from the motor control to the motor. Power is obtained from a Skylab 28-vdc power pigtail which mates directly with a bulkhead connector on the motor control. The design is defined by MSFC Drawing and Parts List No. 95M12007.

b) Venturi. The general shape and size are described in paragraph 2.2.4.1. The two shell halves are spun from 0.040-inch aluminum alloy sheet as are the top and bottom rims. Added stiffness and operator protection is ensured by beading the extreme edges over aluminum wire. The 6-inch wide by 1/8-inch thick aluminum reinforcing band around the throat area provides solid support for the motor mount and for the three hat section brackets which form the principal attachment points. All fastening is accomplished with aluminum rivets except for spot welding the top rim doubler. Faying surfaces of the piece parts are treated with alodine for electrical bonding while the remainder of the assembly is anodized. The upper rim is hard coat anodized for consistency with the electrostatic table finish when it is in operation.

No major changes were made in the venturi drawing after completion except the provisions for mounting the electrostatic table retainers.

All venturi upper and lower shells were made at the same time with the same tooling. Upper and lower contour templates were made and used for inspection and, for puposes of documentation reference, each was assigned a drawing number.

c) Table Assembly. The description as delineated under paragraph 2.2.4.1 did not change. Preliminary tests determined that the stainless steel screen covering should be made of 0.005 diameter wire woven on a 1/2 mm spacing. Retention within the venturi top rim is accomplished with three bolts threaded into clinch nuts on the table rim.

d) Venturi Supports and Brackets. Final configuration of the side and rear struts is as described in paragraph 2.2.4.1. Tubular members are made of aluminum alloy tubing 5/8-inch O.D. and 0.035-inch wall thickness. End fittings and doublers are 0.063-inch thick aluminum alloy sheet. A stress analysis was conducted after the workshop design environments became available and strengths were shown to be more than adequate. To ensure against inadvertent side forces from the operator, gussets were added to the end fittings.

The wall mount brackets (four for the strut attachments and one for the venturi upper rim) were documented in their final design when a major change was made by the Integration Contractor. The pattern of the compartment wall grid was rotated 30 degrees which necessitated the redesign of all five brackets. The faying surfaces were changed from anodize to alodine in compliance with an added interface requirement for electrical bonding. Several changes were made to the mounting hole size as revisions were made to the interface documentation.

e) D. C. Motor and Motor Control Box. A number of changes to the existing D. C. Motor were required by the Principal Investigator which resulted in hardware modification by the vendor. Environmental protection for the motor was provided by the addition of a seal at the output shaft, the tachometer take-off was removed and replaced by a new end bell, and the electrical connector was replaced by one to specification 40M39569 (to be furnished by MSFC).

The motor control box also was redesigned both electrically and mechanically. The speed control switch was changed to indicate OFF, LOW, MED, and HIGH, and the auxiliary vernier control eliminated. Internal circuitry was revised to provide motor speeds established by testing of the prototype at MSFC. When the decision was made to make this box the Skylab electrical interface for M507, two switches were used to control power to either the aerodynamic or the electrostatic workbench. These were electrically interlocked so that both workbenches could not receive power simultaneously. The connectors were replaced by a new set to specification 40M39569 (furnished by MSFC). Since the motor control box was now serving as the 28-vdc distributor for the experiment, a new receptacle was added to its upper wall to service the Electrostatic Workbench. The four-hole mounting on this box would not mate with the compartment grid so an aluminum adapter plate was designed by Chrysler to become the interface.

f) Motor Cable. It was originally anticipated that the motor and control manufacturer would furnish the interconnecting cable. This did not prove to be the case and Chrysler was directed to document the item. Individually insulated wires were specified to be enclosed with Icore convolute tubing and terminated with mating 40M39569 connectors.

g) Motor Support. The method of supporting the motor is similar to that planned when installation by the astronaut was still required as the possibility exists that this subassembly might have to be replaced prior to lift-off. Simple motor struts are assembled with two bolts to each of the four motor mounting flanges. Each of the struts has two slots for the bolts in one end and a bolt hole in the outer end. Four mounting brackets are located in the venturi throat and are riveted in place. These brackets have receiving slots parallel to the venturi axis and terminated by a mechanical stop on the end towards the venturi exit. The motor/fan subassembly, with struts loosely attached, is lowered through the venturi intake and the strut ends mated with the bracket slots. Assembly bolts are inserted through the slot fingers and matching strut end holes. Adjustments are made to equalize fan blade tip clearance and plane of rotation to compensate for the sheet metal fabrication tolerances. With the strut/motor flange bolts tightened and match marks applied to one strut and bracket, the four assembly bolts are removed, the motor/fan subassembly demounted, and permanent dowels pressed through the strut/motor flange interfaces. Now the motor can be mounted or demounted for shipping or any other purpose.

h) Exit Screen. At the Preliminary Design Review, a potential safety hazard was brought up for consideration. This involved the possibility of debris, tools, or other foreign material drifting into the proximity of the fan through the venturi exit. The hazard was eliminated by the design of an exit guard, the composition being the same as that of the table assembly. The guard is held within the exit by retaining clips and is notched to receive a grommet through which the motor cable can exit from the venturi.

2.2.5 Weights and Center of Gravity

Table 1 lists weights and center of gravity calculations for both the aerodynamic and electrostatic workbench. Weights listed for the aerodynamic workbench are estimated because fabrication of the qualification unit was not sufficiently advanced to permit measuring actual weights; those listed for the electrostatic workbench are actual weights. Figures 9 and 10 show the physical relationship of the aerodynamic and electrostatic workbenches and the physical relationship of their subassemblies. The center of gravity locations given in the table 1 are measured from the reference points or planes indicated on these illustrations.

2.3 PHASE IIA - ENGINEERING PROTOTYPE

2.3.1 General

The construction of the prototype, the force test fixture, testing, safety program and late developments are discussed in the following paragraphs.

2.3.1.1 Construction

2.3.1.1.1 Ion Source and Shield. The test results and the derived criteria of Phase I-Study regarding the configuration of the ion shield were very convincing. It did appear that the density and distribution of ions directed to the table top might be influenced by the location of the ion emitter within the shield and that its proximity to a grounded object at the cover might be critical to discharge. For this reason, the general contour of the prototype shield was made identical to the proposed final design. The central insulator and the

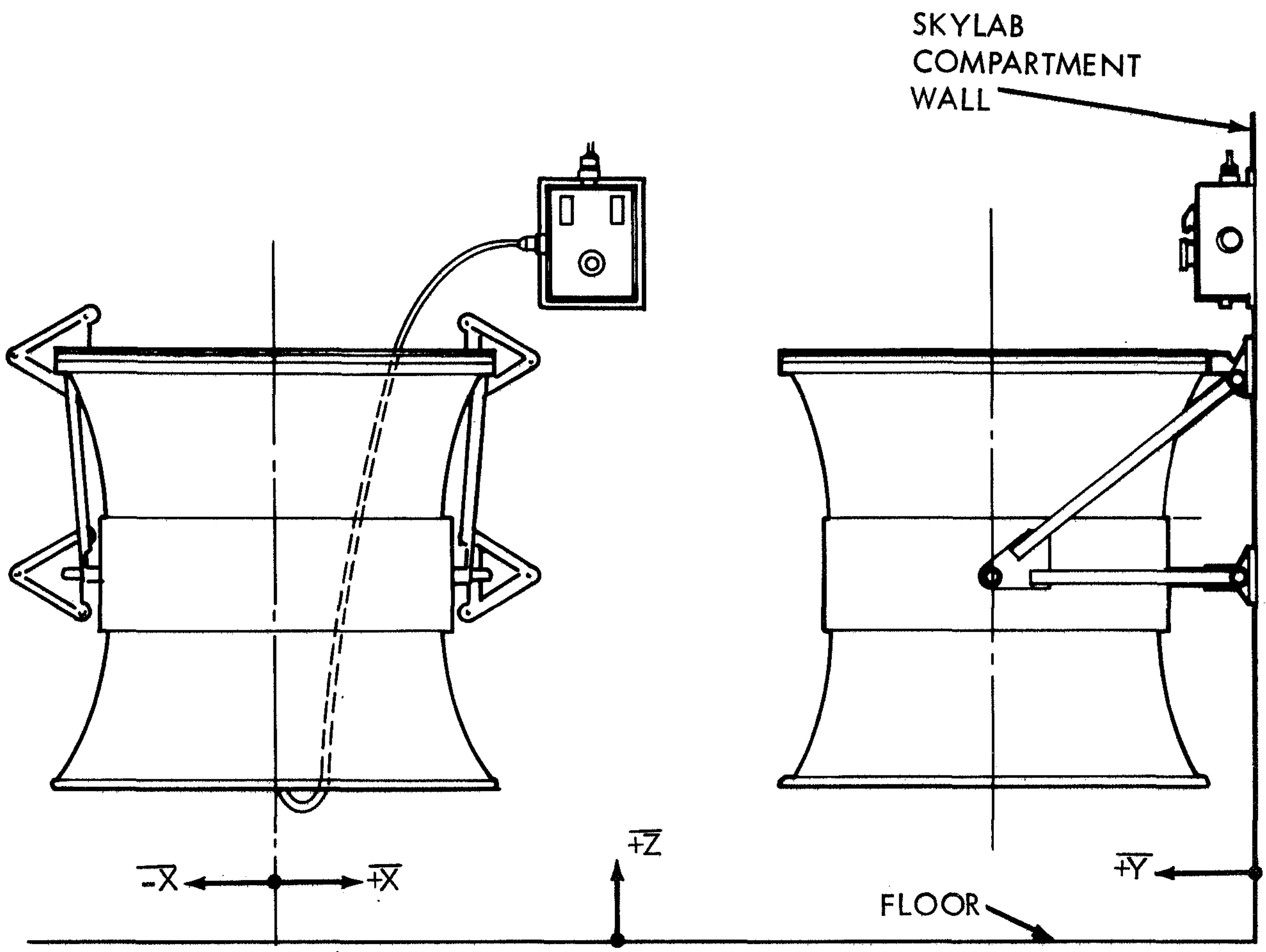


Figure 9. Aerodynamic Workbench

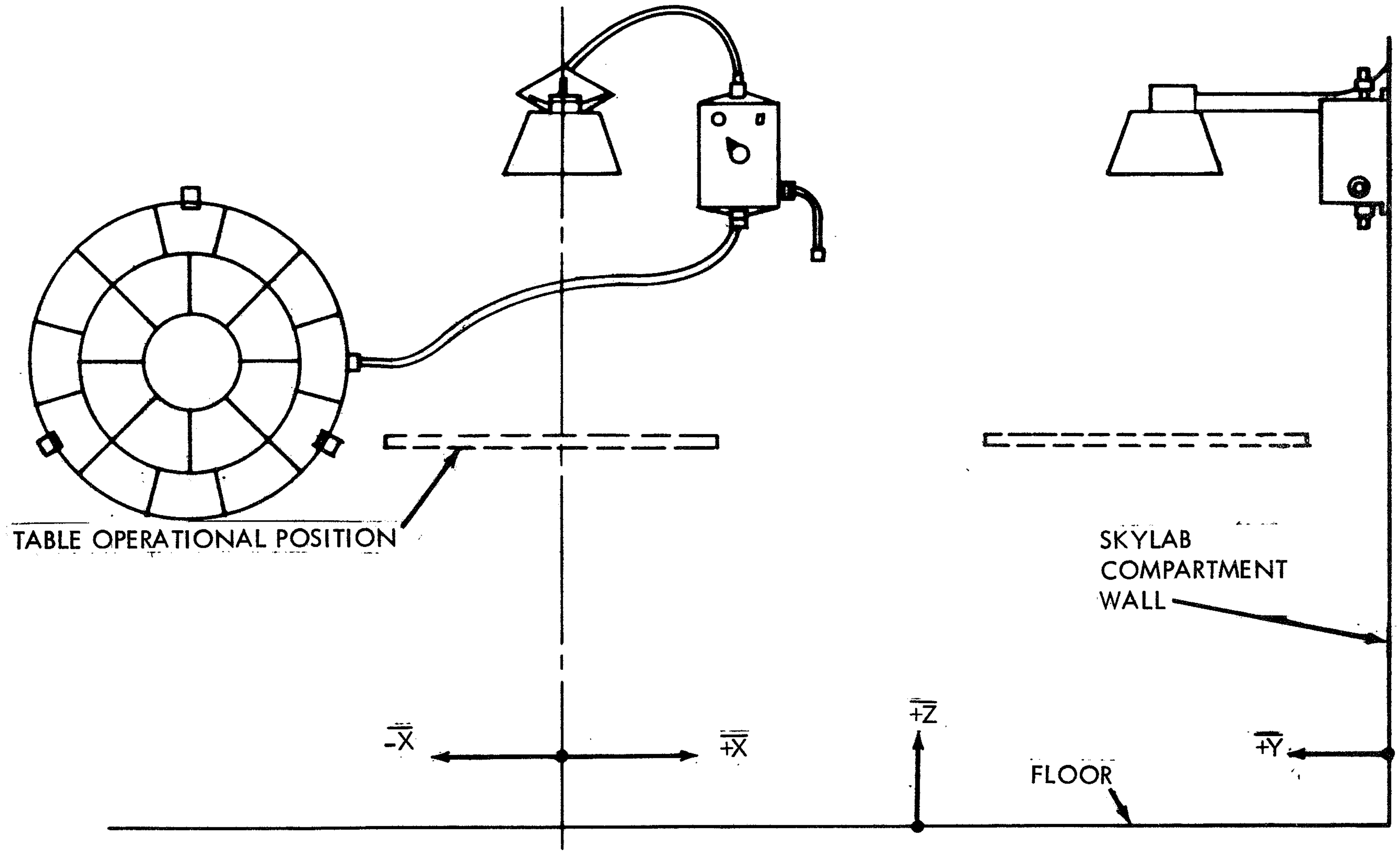


Figure 10. Electrostatic Workbench

MAJOR COMPONENT	WEIGHT (LBS)	LAUNCH CONFIGURATION (INCHES)			OPERATIONAL CONFIGURATION (INCHES)		
		$\bar{X}$	$\bar{Y}$	$\bar{Z}$	$\bar{X}$	$\bar{Y}$	$\bar{Z}$
1. AERODYNAMIC WORKBENCH	35.27	+3.08	11.38	34.20	+3.08	11.38	34.20
A. VENTURI, TABLE TOP, STRUTS, EXIT GUARD, MOTOR, FAN, AND ALL ASSOCIATED BRACKETS	29.30	0	13.29	31.53	0	13.29	31.53
B. SPEED CONTROL AND CABLE	5.97	+18.20	2.00	47.65	+18.20	2.00	47.65
2. ELECTROSTATIC WORKBENCH	17.73	-0.87	3.51	57.85	+3.26	5.65	57.20
A. ION SOURCE, SHIELD, SUPPORT AND BRACKET	3.28	0	11.50	63.00	0	11.50	63.00
B. ELECTRONIC ASSEMBLY AND CABLES	9.70	+10.90	1.80	62.10	+10.90	1.80	62.10
C. TABLE TOP AND CABLE	3.20	-24.30	1.50	45.56	-0.90	13.30	42.00
D. STORAGE BRACKETS	1.55	-28.10	1.50	45.56	-29.10	1.50	45.56
3. M507 EXPERIMENT	53.00	+1.76	8.75	42.10	+3.14	9.45	42.00

M507 LAUNCH CONFIGURATION
AND AERODYNAMIC ONLY OPERATION
ELECTROSTATIC ONLY OPERATION

TABLE 1. WEIGHTS AND CENTER OF GRAVITY

ion needle within it were made as a separate movable subassembly, within a hub to vary the needle position along the shield axis. Available needle point-to-cover distance was 1 9/16 to 3 7/16 inches. The cover was fabricated to the Phase I criteria; i.e, 1/8 inch holes on 1/2 inch centers. The block and cap to enclose the needle, clamp the high voltage cable, and attach to the support were made to the intended final configuration. Teflon was used for all of these non-metallic parts.

2.3.1.1.2 Support and Bracket. The support was fabricated of polyimide resin fiberglass laminate to the dimensions of the final design. The bracket to attach the entire ion shield and support to the wall was built to the 3-hole mounting pattern and was not changed when the compartment wall was revised.

2.3.1.1.3 Power Supply and Cable. The prototype power supply configuration developed slowly as problems with the internal packaging were identified and corrected. After several unsuccessful high voltage modules were built, the one that became the prototype very closely duplicated the final design. The major departure was the high voltage cable, which had a polyethylene jacket since a better choice was not available at the time. The bond between the polyethylene and the E-C 2850 GT potting compound was marginal but gave satisfactory laboratory service of several hundred hours.

The low voltage printed circuit boards represented the final design except that some of the electronic components were commercial quality. Because the prototype was not intended to undergo exposure to environmental extremes and some facility for making changes was desirable, it was decided not to pot the high voltage module and low voltage section into the case. Externally, the power supply was in close agreement with the formal design although the 28-vdc input cable was of temporary configuration.

2.3.1.1.4 Table Top. As previously mentioned, the hard coat anodized aluminum had given better electroadhesive results than the porcelainized steel. It was believed that more formal proof of this advantage was necessary, and for this reason, table tops of both materials were fabricated for evaluation. The aluminum top was built essentially to final design. The porcelain top was furnished with a teflon insulating ring completely encircling its rim and guarding against edge chipping.

2.3.1.2 Force Test Fixture

A rather crude force test fixture had been devised during the Phase I work consisting of the table surface supported in a vertical plane and the ion source and shield mounted to operate on a horizontal axis with the table. A brass test disk was suspended by thread at the table surface and was attached to a horizontal thread, which in turn was knotted to another vertical thread. This latter thread supported a dead weight from a movable point. As this point was moved away from the table and its neutral position, a component of the dead weight appears as a force on the horizontal thread. The distance traveled by the movable point is related to the force necessary to overcome the electroadhesion developed at the disk by the known geometry of the suspension system. The basic principle and operation of the fixture was sound and straightforward, but its flexibility was believed to be responsible for the erratic data produced.

A new fixture was built, similar to the original, but with a rugged aluminum angle framework. (see figure 11.) The side representing the OWS compartment wall was made of a section of the standard Apollo grid. One end was covered with plywood to which a sample venturi upper ring was attached so that the table surface could be mounted in the intended relationship. A sturdy aluminum beam was designed to support all the test disk suspension system, a trolley for the movable point, a motor/pulley arrangement for remote operation, and a scale to determine the amount of movable point displacement. Thus, the entire beam assembly could be moved as a unit, and a survey made of forces across the table surface if desired. Varying the dead weight or the geometry could be used as a scale factor. For purposes of measuring the electroadhesive force on ungrounded objects, the thread was to act as an insulator although some surface charges would gradually leak off. The overall fixture was small enough to be bench mounted or to fit within the environmental test chamber.

2.3.1.3 Testing

The test data of Phase I proved that the forces produced by attraction, although considered useful in a zero-g environment, were quite small (in the range of several hundred dynes) and would therefore be difficult to instrument. For the Phase I demonstration, a ping-pong ball was suspended in the ion cloud about 5 inches from the table. Its deflection towards the table was measured optically and the force calculated. It was reasoned that if the proper flow of ions is being generated, that fact will be evidenced by the presence of electoadhesive force between the test disk and table. These electroadhesive forces were anticipated to be in the 1 to 30-gram range and much easier to measure. Therefore, the prototype testing was confined to the measurement of electroadhesive force, either by the voltage bias method or with the ungrounded disk, in the force test fixture.

2.3.1.3.1 Initial Tests. The two prototype tables were the first items available for test and they were checked by the direct 300-volt bias method. Several different spots on each table were tested and surface cleaning methods were experimented with. The average force of the test disk on the porcelain steel table was 3.2 grams and for the hard coat anodized aluminum table 46.0 grams. There was a rather high dispersion of readings which could not be attributed to the cleaning method.

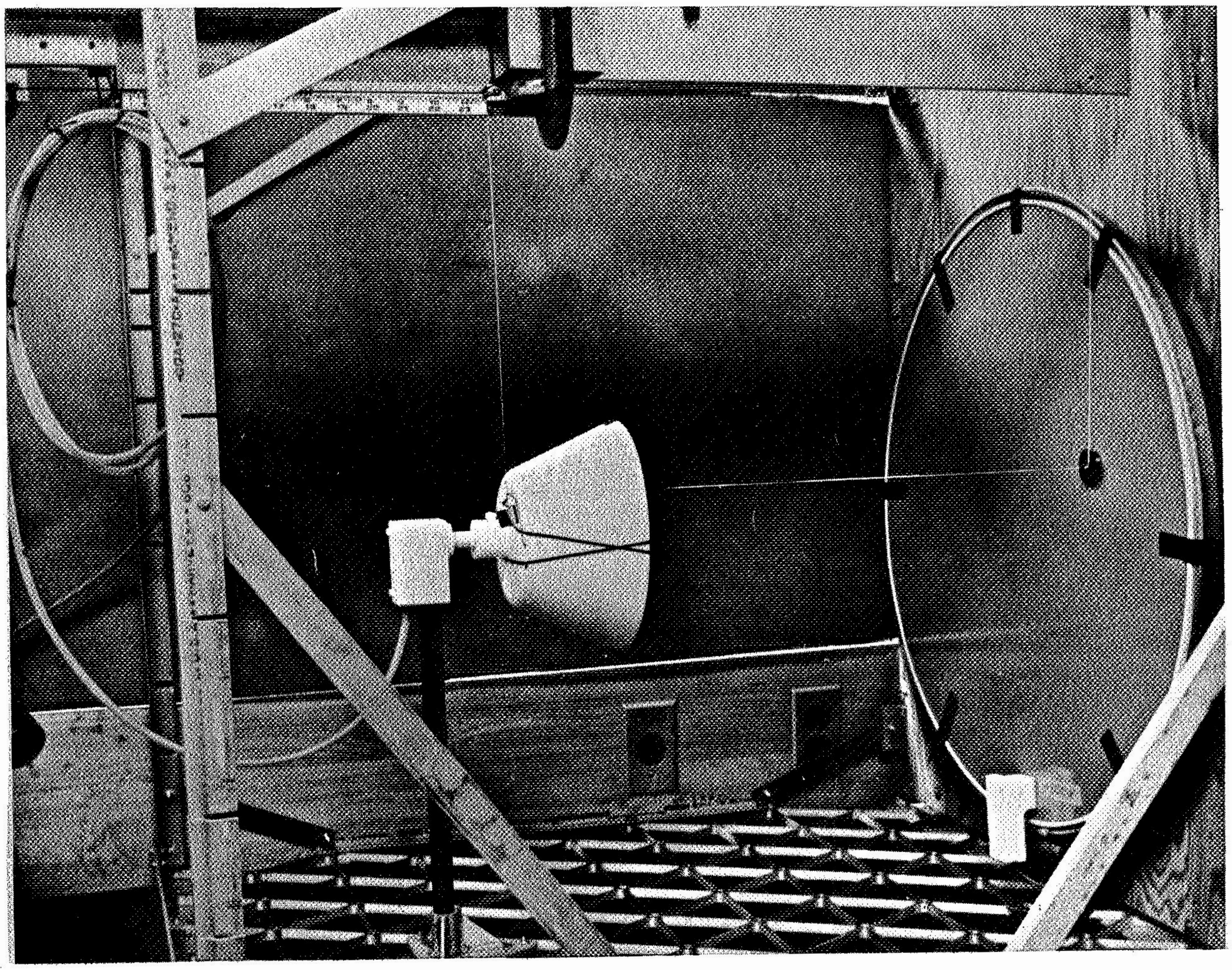


Figure 11. Force Test Fixture

After the shield, ion source, support, and mounting bracket became available, they were assembled and connected to the laboratory high voltage supply. Tests were performed with voltages of 40, 50, and 60kv at atmospheric pressure and progressively moving the ion point back from the perforated cover. A grounded lead at the outside surface of this cover was used to assess the tendency to spark. Sparking ceased at a distance of 1.95 inches for 40kv, at 2.95 for 50kv, and continued at 3.4 inches (max. available adjustment) for 60kv. Since operation in the Skylab will be limited to 40kv at 5 psi, it was deduced that a distance of 2.43 inches would be satisfactory. The position of the ion emitter did not have an appreciable effect upon "focusing" the ion beam at the work surface.

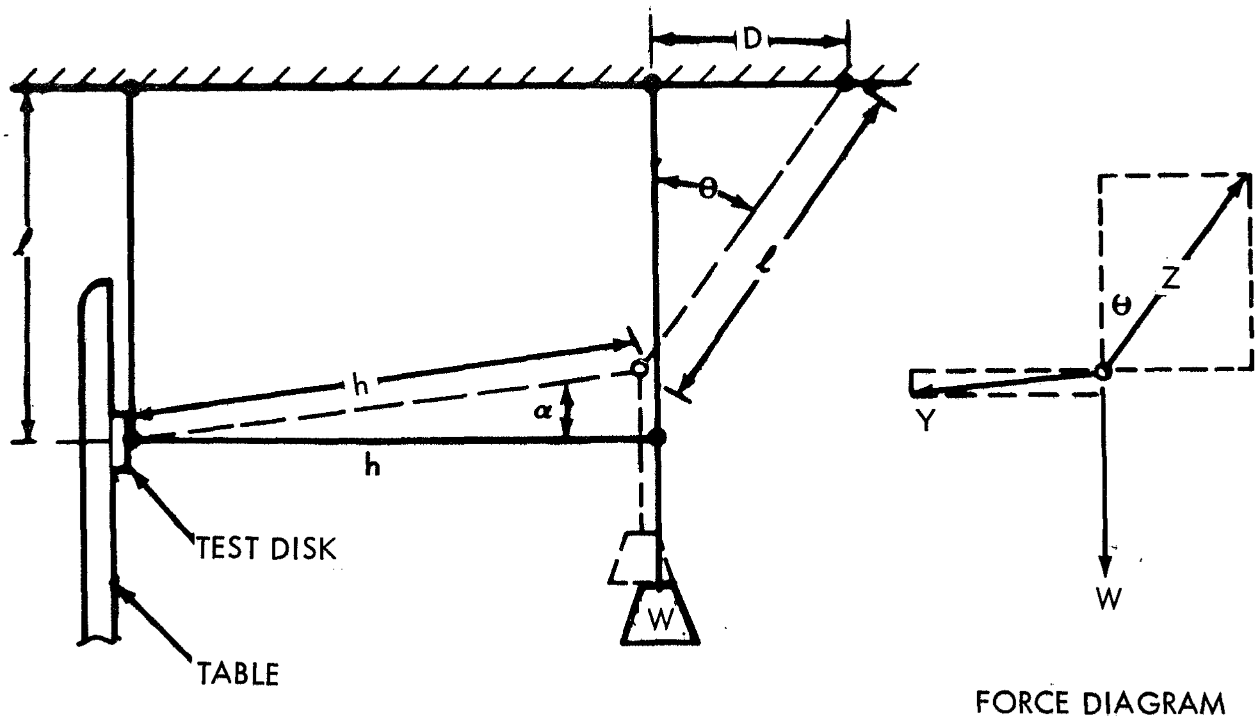
A period of familiarization with the operation of the force test fixture followed and the steps which seemed to be necessary to produce consistent results were developed. The basic measuring geometry and method of computing the electroadhesive force is illustrated in figure 12. It was possible that relative humidity and temperature could have a marked effect on the test results, so these criteria were noted in subsequent tests.

2.3.1.3.2 Table Comparison Tests. A series of tests were next run to compare the two prototype tables. Test disk locations were chosen in groups of two on both sides of the table center and along a horizontal center line. The entire fixture and prototype were then rotated 90 degrees with the measurement beam reinstalled on the new top side of the fixture. Thus, two series of test measurements could be taken at 90 degrees to one another. There were 5 to 8 measurements taken at each location as a variability as high as 2 to 1 was sometimes observed. Table 2 is a summary of the test data:

Table 2. Test Data Summary

Measurement Position	Porcelained/steel (Grams)	(No. of Measurements)	Anodized Aluminum (Grams)	(No. of measurements)
A	3.47	(5)	6.17	(7)
B	3.34	(8)	4.09	(7)
C	3.84	(7)	5.62	(7)
D	1.65	(6)	2.54	(6)
E	9.11	(6)	6.53	(6)
F	7.05	(7)	13.76	(6)
G	9.14	(6)	13.20	(7)
H	10.64	(5)	4.94	(6)

These tests were run with 60kv on the ion source in an attempt to correlate results to those of Phase I. After each measurement, the test disk was reset to table contact by hand and a charging time of 30 seconds allowed before taking the next reading. As can be seen in the table, the apparent distribution varies widely and does not set a clear pattern. The lowest average reading for both



ASSUME THAT FOR SMALL ANGLES OF α,

F (THE CALCULATED FORCE) = Y

Σ HORIZ.: $Y \cos\alpha = Z \sin\theta$ OR $F = Z \sin\theta$ (APPROX.)

Σ VERT.: $W + Y \sin\alpha = Z \cos\theta$

$$\tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{F}{W + F\sin\alpha} \quad \text{AND} \quad \tan\theta = \frac{D}{\sqrt{\ell^2 - D^2}}$$

$$F\left(\sqrt{\ell^2 - D^2}\right) = DW + DF\sin\alpha = DW + DF\,\frac{\ell - \sqrt{\ell^2 - D^2}}{h}$$

SIMPLIFYING,

$$F = \frac{DWh}{\sqrt{\ell^2 - D^2}\,(h+D) - D\ell}$$

Figure 12. Force Measuring Geometry and Computation

tables occurs at position "D" which might imply that the ion supply is low in that region. Although these measurements were taken over a number of days, the room temperature was observed to vary less than 5°F and the relative humidity less than 10 percent. Calculating the overall measurement average for the two tables, the porcelain/steel produced 5.8 grams as compared to 7.1 grams for the hard coat anodized aluminum.

Another but shorter series of tests was conducted with charging times of two minutes. The results showed variations just as wide and forces of less magnitude.

An analysis of causes for the inconsistent measurements in the face of an improved test fixture, better test procedures, and more attention to test conditions revealed the following potential causes:

a. Local variations in electroadhesive film thickness
b. Local variations in film density
c. Local variations in film roughness
d. Local variations in film contaminants
e. Variations in disk residual charge and rate of ion build-up
f. Variation in ion cloud density
g. Atmospheric effects such as temperature, relative humidity, pressure, contaminants, or ionic content
h. Secondary ionization
i. Other effects as yet unidentified

During this period, the search for instrumentation to assist in evaluating the ion phenomena and the design developments was intensified. One instrument, the Static Meter No. CMI-7777 by Custom Materials, Inc., is said to measure static charges on surfaces and field strengths but did not prove to be of help in this application, perhaps because it is hand-held a few inches from the surface of interest and the ion cloud was blocked or disturbed. An air ionization indicator, built from experimental plans, was capable of detecting the presence of predominately positive or negative ions. Its sensing chamber was large and attached to a box; its presence in the ion cloud created some distortion and precluded any other simultaneous measurements. Although, the latter instrument was not intended to give quantitative readings, it did indicate the ion wind effect (wave of ions) as the emitter is turned on or the voltage stepped upward.

2.3.1.3.3 Prototype System Testing. When the prototype power supply became available and was incorporated in the system, excessive leakage was present around the top of the shield and also the previously noted inconsistency of test results was continuing. The first problem was countered by modifying the shield-emitter configuration. The adjustable emitter feature was removed and the entire shield, emitter, block, cap, and high voltage cable interfaces were cemented to simulate the intended final design configuration. The emitter point-to-perforated cover distance was set at 2.43 inches.

Secondly, it was theorized that an ion accelerator effect was needed (similar to the grid in a vacuum tube) and several configurations of wire grid external to the shield were tried without success. With the perforated cover removed, it was very evident that an ample supply of ions were being produced to the extent that everything in the vicinity became charged. This and the increase in power supply current had been noted in the Phase I Study. The conclusion was that the density of ions within the shield was building up a charge on the inside of the cover to the point of choking the ion flow through the 1/8-inch holes and thence to the table.

An intensive program was initiated to determine the requirements of an effective bleed system. A conductive grid pattern would have to be connected to ground potential through a high resistance. Many configurations were tried and included: simple crosses, square waves, and Greek crosses, both open-ended and closed as well as magnet wire and copper tape. Because of the existing pattern of 1/8-inch holes and the circular boundary, it was difficult to design a bleed pattern that would have a uniform effect across the cover. There was some experimentation with patterns impinging on holes and with hole size but this was dropped because of practical considerations of fabrication control. The Greek cross combined simplicity and effectiveness when made of 1/8-inch wide copper foil. An optimum value of bleed resistance (about 10,000 megohms) was determined, as too much bleed would drain off useful ions and too little would permit choking.

Experimentally, these patterns were cemented to the outside of the cover and insulated. They were tried internally also but were found to be too effective. From a practical standpoint the bleed conductor would have to be sandwiched with an external sheet of teflon using epoxy adhesive. Various thicknesses were tried and 0.010-inch proved to be the best compromise between an adequate insulation value and becoming less effective as a bleed. This cover/bleed design gave more consistent results at higher average forces than had been obtained before, although the repeatability problem had not been completely solved.

To aid in evaluating the bleed development some additional instrumentation was installed which enabled a readout of the bleed circuit current, the table bias current, and the power supply current. It was found that a low bleed and power supply current were desirable. A schematic of the current measuring circuits is shown in figure 13. At the same time the table current should be high as it implies that a good supply of ions are reaching the table. However, this is not a direct indication that electroadhesion will occur as it is a function of many other factors. When operating at 40kv, typical values of current are: 0.15 to 0.30 microamps for the table and 1.8 to 3.0 microamps for the power supply and bleed circuit.

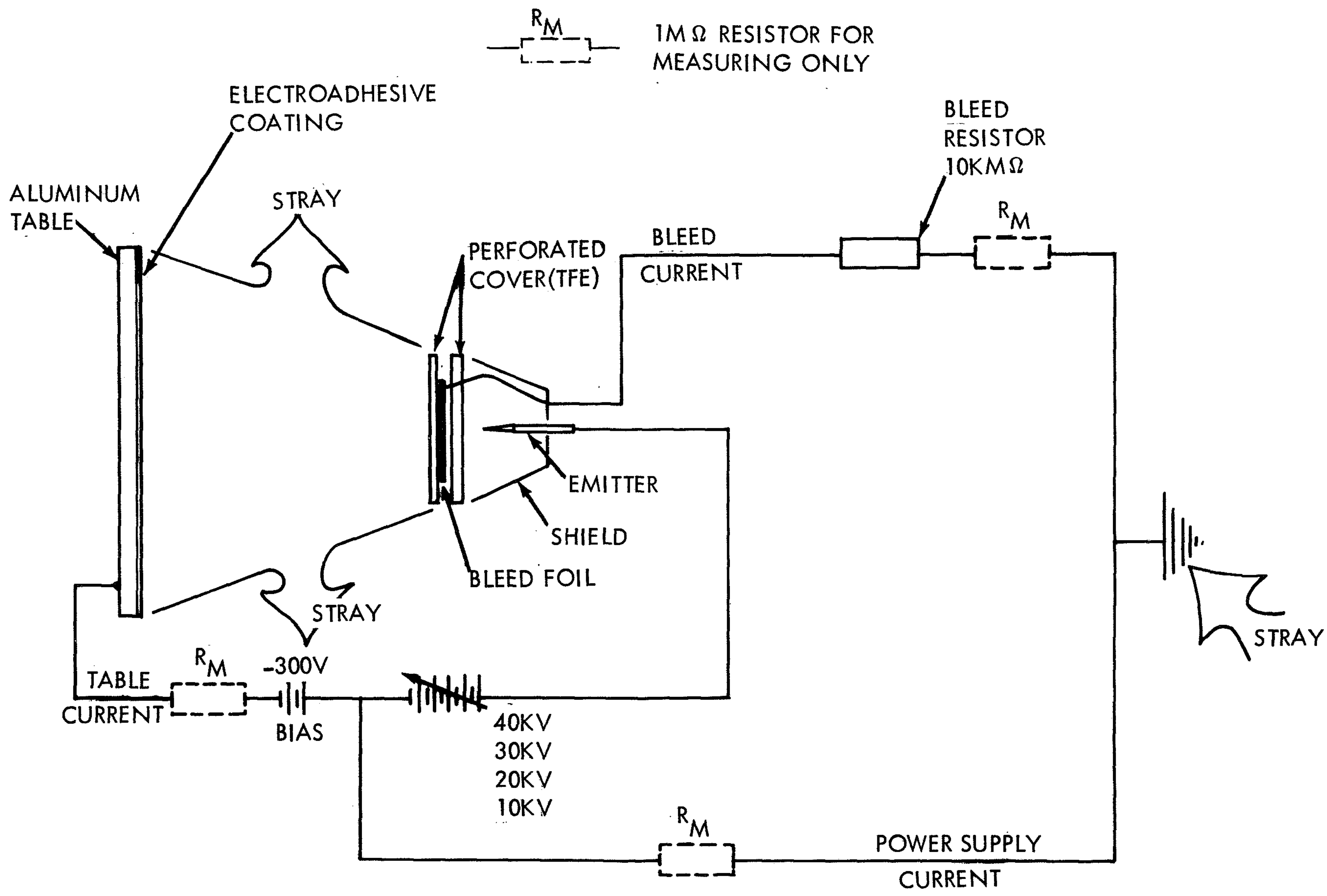


Figure 13. Current Measuring Schematic

Another useful instrument is the electrostatic voltmeter (Singer No. ESH) fitted with a probe made from a connector contact pin. The voltage gradient across the shield cover could be surveyed and compared with the potential at the inside surface of the cover. This became the basis of the only simple test that could be performed once the workbench is installed in Skylab to prove that ions are being produced and that the voltage selector switch is operational. With a probe modification, the electrostatic voltmeter was also used to investigate the field potential from shield cover to table and the charge distribution parallel to the table.

2.3.1.3.4 Other Testing. The following paragraphs describe other testing that was performed due to the results of the previous tests.

a) Electrical Shock. During the testing described in paragraph 2.3.1.3.3, it was observed that under certain conditions an operator working within the ion cloud could experience an electrical shock comparable to touching a door knob after walking across a carpet in dry conditions. A grounding cuff was devised by using a metal watch band attached to a ground wire; this proved to be very effective.

b) Electromagnetic Interference. A limited amount of electromagnetic interference (EMI) testing was conducted to establish the requirements for the 28-vdc line filters. Additional internal redesign and testing for EMI reduction was not attempted for several reasons as it was not anticipated that the generated interference would be of a magnitude or bandwidth to cause a serious problem. The addition of new filtering components and/or the revision of existing components would most likely alter the desired functional characteristics and would require a new round of redesign and breadboarding.

c) Table Top Comparison. The three deliverable table tops produced under Phase III of the contract were tested and compared to the prototype table top using the prototype power supply and emitter. A fairly wide range of force values were recorded for all table tops, but the averages of the new tops were definitely lower than that of the prototype. The thickness of the hard coat anodize could not be reliably measured by available nondestructive methods; however, the associated test coupons indicated a slightly thicker coating on the new tops than the specified 0.002 inch of the prototype. For this series of tests, numerous measurements were taken at one spot on each table, then the table rotated 180 degrees and measurements repeated at the new location. The effect of local surface cleaning was briefly investigated but results were not consistent. The average forces obtained in these comparative tests were as listed in table 3.

Table 3. Table Top Comparison

Table Top	Table Oriented 0 Degree, Spot Cleaning, Before (Grams)	Table Oriented 0 Degree, Spot Cleaning, After (Grams)	Table Oriented 180 Degrees, Spot Cleaning, Before (Grams)	Table Oriented 180 Degrees, Spot Cleaning, After (Grams)	Overall Average Force (Grams)
Serial No. 1	11	15	11	23	15.0
Serial No. 2	7.4	11.9	12.7	13.2	11.3
Serial No. 3	15.8	16.2	6.2	12.0	12.5
Prototype	26.0	27.8	22.0	--	25.2

Each of the listed force values is the average of 4 to 8 individual readings taken at each spot. The cleaning compounds used were alcohol and freon. Note that, although the post-cleaning averages were always greater, the percentage increase ranged from 4 to 105 percent and the tables had been given an overall cleaning before any testing.

d) Experiment Object. The test object to be assembled and disassembled under the influence of the M507 workbenches was a modified Bimba air cylinder. This object was chosen by the Principal Investigator because it was composed of parts having a wide range of shapes and materials. A sample cylinder was disassembled and the component parts suspended at the table surface. A typical machine screw was treated in the same manner. Since some of these parts in certain orientations would present theoretical point or line contacts to the table surface rather than an area of appreciable size, the electroadhesive forces generated would be comparatively small. The regular motor-actuated force measuring feature of the force test fixture was not satisfactory. A hand held spring scale and careful attention to thread attachment proved to be an adequate method of measurement. The results of these tests are presented in figure 14.

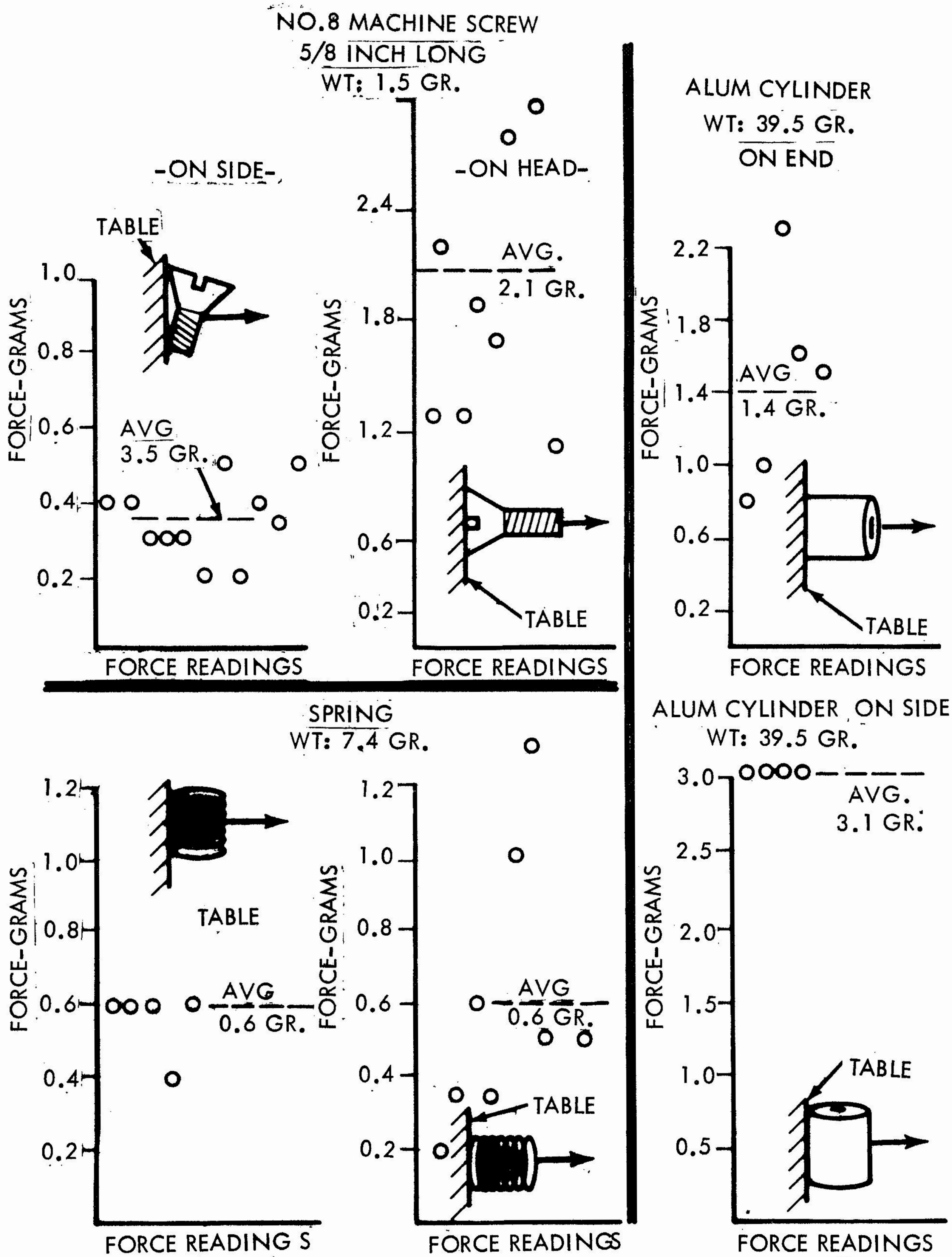


Figure 14. Test Object Forces

Other parts of the test object were also checked with their flat sides against the table; the rod sleeve (aluminum) produced 10 grams, the piston and seal (stainless steel and buna rubber) 11 grams, and the cap (aluminum) 12.8 grams. The spring guide (teflon TFE) was very difficult to instrument with threads for testing and useful results were not obtained.

2.3.1.4 Safety Program

2.3.1.4.1 Initial Philosophy. The testing and analysis reported in the Phase I Study covered electrical shock, radio interference, ozone production, ultraviolet and X-ray radiation, and flammability. Both the Principal Investigator and CCSD were of the opinion at that time (May 1969) that this work was convincing and responsive to the known hazards. For this reason, a modest test and analysis effort was planned during the subsequent contract phases.

In December 1969 NASA-MSC transmitted a critical review of the Phase I safety effort to MSFC who passed it on to CCSD. Basically, MSC believed that additional test proof was required. As a result of this communication, CCSD developed plans for a series of tests to verify certain safety aspects and which were to be conducted in conjunction with a demonstration for interested parties.

2.3.1.4.2 Interim Testing. Although CCSD realized the desirability of testing for the production of ozone and x-rays in an oxygen-rich 5 psi atmosphere, facility restrictions would not permit this exposure combination. Plant safety regulations ruled out the use of an oxygen-rich atmosphere within a plant-installed pressure chamber. A simple chamber of approximately 30 ft^3 volume was built and installed at the CCSD Remote Test Site. However, it was not capable of reduced pressure operation. A pre-mixed gas (80% O_2, 20% N_2) was introduced and circulated slowly by an integral fan. Ozone production was measured by a Mast Development Company ozone meter and recorder. X-ray film strips were attached to the test article which had been installed in its operational relationship. The test consisted of a 12-hour power-off baseline run followed by a 12-hour power-on run with the workbench operating at its maximum capacity of 40kv. The ozone level built up to 5 PPHM which was considered to be acceptable by most standards. However, the x-ray film produced no results and was subsequently declared defective by the furnishing laboratory. Details of this test are available in technical report TR-EE-70-41 "Ozone and X-ray Test Report for Gravity Substitute Workbench (Electrostatic) NASA Drawing No. 95M12015."

2.3.1.4.3 Safety Review and Demonstration. A Safety Review and Demonstration was held at CCSD on May 26, 1970 with 23 representatives from NASA-HQ, NASA-MSC, NASA-MSFC, and Chrysler attending. The principle of operation and configuration of the workbench was described and the results of the ozone/X-ray tests were presented. A demonstration of the prototype unit followed with electrostatic voltage and electroadhesive force measurements. Some of the visitors participated in exploring the potential for electrical shock under intentionally worst-case conditions. The general concensus was that the CCSD effort to date had not satisfactorily demonstrated that the workbench was safe for flight use. Particularly damaging was the fact that MSC had made a new and highly detailed hazard analysis which was made known to CCSD only a few days prior to this review. MSC/Crew Systems categorically stated that even a minute shock was unacceptable, which would make an ankle or wrist grounding strap mandatory.

2.3.1.4.4 Expanded Program. The next step was the formulation of an expanded safety plan that would be responsive to the new hazard analysis and the criticisms of the demonstration. Major changes in requirements involved longer exposure to oxygen-rich 5-psi environment while detecting production of ozone and X-rays, and an additional test for presence of ultraviolet. The ultraviolet was not considered a direct hazard to the astronaut but any radiation might falsely trigger the fire detectors being considered. A device to purposely induce electrical discharge was to be attached during test to create a worst-case condition. A grounding cuff was to be designed and evaluated. Methods of reducing the chances of touching the perforated shield cover were to be investigated. The effort to accomplish a program of this magnitude was obviously beyond the scope of work costed for the existing contract. The Safety Plan and its cost impact were submitted to the customer on July 9, 1970 as CCSD Proposal No. MI-148-A. Due to the funding increase required and with the continued flight status of the experiment in doubt, the proposal was never acted upon favorably. CCSD was officially notified on October 9, 1970 that funding for this proposal would not be available.

2.3.1.5 Late Developments

The problem of inconsistent electrostatic force measurements during the early prototype testing (ref. 2.3.1.3) has been described. The discovery that a choking effect on ion flow was occurring at the ion shield cover and the bleed system developed to alleviate the problem was covered in paragraph 2.3.1.3.3. Although a marked improvement in performance was noted, it was realized that the pressure of schedules did not permit optimization of the design. The incident which took place during the Qualification Test (see Appendix C), wherein nearly all evidence of electroadhesive force was lost when fresh suspension threads were installed, gave further indication that the available ions at the test disk were probably marginal and that the condition of the attaching threads was more critical than suspected.

CCSD was directed to complete their contract commitment of fabricating, testing, and delivery of the Qualification, Flight, and Back-Up Units. Without interference with that commitment some additional testing was performed with the Prototype Unit in search of answers.

2.3.1.5.1 On the theory that ions resist passing through small holes of any great length, the cover holes (1/8 inch diameter through 0.140 inch thickness) were countersunk from the inside surface, leaving only 0.010 to 0.020 inch of the original diameter intact. This modification resulted in a 10 to 15 percent improvement.

2.3.1.5.2 A theory was proposed that the clean monofilament nylon thread collects sufficient (+) ions to deflect new ions away from the test disk. When the horizontal thread (through which test force is applied) was relocated to a point about six inches above the disk, a marked improvement in disk charge was indicated. However, this arrangement introduces a variance in measuring the force on the test disk because of the lateral force component which causes a sliding and peeling action on the disk.

2.3.1.5.3 An experimental cover was constructed of No. 28 gauge teflon insulated wire, woven to a 1/8-inch spacing. As compared to no cover at all with a table current of 1.5 microamps, this cover produced a current of 1.3 microamps, and also operated just as well with the bleed lead circuit open.

A simulated multiple emitter was constructed by adding four copper wire points to the original emitter. This produced a table current of 2.0 microamps.

These results were encouraging and, although the development testing to date has been limited, they indicate that considerable improvement in performance can be achieved.

2.4 PHASE III FABRICATION AND QUALIFICATION

This part of the discussion is organized to reflect the principal subjects covered in the contractual Scope of Work.

2.4.1 Deliverable Units

Three identical units were fabricated to released documentation; these were identified by the names Qualification Unit, Flight Unit, and Back-Up Unit. Minor differences did occur internally, mostly due to changes in processing, without any significant effect on performance. To ensure the fabrication of identical units, several CCSD internal procedures were issued. One document detailed the routing of parts and assemblies from raw stock or purchased finished part to final unit assembly and test. A second document issued a series of process sheets. When an operation involved an in-process test, the test requirements were spelled out in detail on an auxiliary procedure. An additional aid was provided by graphically depicting these operations on a schedule chart and clearly showing the sequence and interrelations of events. A third document specified the action and control forms that were to be used and their routing through the appropriate organizational elements.

2.4.2 Electrostatic Workbench

2.4.2.1 Quality Assurance Requirements

The contract required Chrysler to maintain an inspection system that would satisfy the requirements of NASA Quality Publication NPC 200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services." A responsive Inspection Plan was drafted and submitted to MSFC for approval in December of 1969. A few minor revisions were incorporated by request and approval was granted on March 11, 1970. The Inspection Plan is included in this report as Appendix A.

2.4.2.2 Reliability Requirements

The parts and materials selected during the design phase remained essentially the same. Minor changes were made to metallic specifications because of availability problems. Revisions to the high voltage diodes, such as increasing the molded body dimensions and improvements in manufacturing techniques and controls, were directed towards increasing the reliability. These changes were not handled by ECP/SCN as formal documentation approval was not involved.

Equipment logs on format MSFC-LH Form 2A were initiated for each of the deliverable units at a point where the high voltage module began to assume an identity as an assembly. They were maintained up to MSFC acceptance of the completed unit.

Failures or malfunctions outside of specification which occurred during the fabrication and testing of each unit were recorded on Inspection Squawk Sheets. Analysis of such failures was performed prior to disposition recommendation and consideration of the need for corrective action. A Reliability Report is included as part of Appendix B.

A Failure Mode Effects, Criticality, and Analysis study was made and was in close agreement with an independent FMECA performed by MSFC personnel. The FMECA is duplicated as Appendix B of this report.

2.4.2.3 Test Requirements

2.4.2.3.1 Qualification Test. In the development of the "Qualification Test Specifications and Procedures for Electrostatic Gravity Substitute Workbench" document, the "Cluster Requirements Specification No. RS003M00003-OWS Design Requirements" was used as a guideline. Certain of these environments were not considered to be applicable while others were planned to be covered as part of the Safety Program. Those qualification test exposures which were chosen as most critical were: electromagnetic interference (EMI), high and low temperature soak, reduced pressure soak and 5 psi operation, and vibration. A draft of this document was submitted to MSFC for approval on July 22, 1970 and approval was granted on August 21, 1970. Appendix C contains a copy of this specification.

2.4.2.3.2 Acceptance Tests. The contract also required that the functional acceptance tests were to be approved by MSFC prior to their use for deliverable hardware. It was decided to incorporate these as Appendix I of the Qualification Test Specification and Procedure. These tests were divided into two groups: those which could logically be applied to the Power Supply at that stage of fabrication and those which could be applied to the final workbench configuration. One of the latter tests is suitable for in-plant checkout where the force test fixture must be used, while the other requires only an electrostatic voltmeter and probe; this could be employed at any location including the Skylab installation.

2.4.2.4 Configuration Control

It is of interest to note that the normal relationship of formal reviews to contract activity did not exist on this project. The Preliminary Design Review which normally is concerned with preliminary specifications and requirements prior to concept layouts did not occur until four months after the final design was essentially complete. The Critical Design Review considers the completed design documentation and, if satisfactory, results in approved drawings to be released for the fabrication of deliverable hardware. This review never occurred although a CDR for the Skylab system was held in mid-September 1970; Chrysler did not attend. The Configuration Inspection usually is scheduled just prior to hardware delivery. Because of the experiment status at the time, this activity became an informal inspection and provisional acceptance prior to delivery.

It was recognized early in the program that the scheduled CDR date was not compatible with the required fabrication schedule. Consequently, it was agreed that, after a review of a drawing or specification by the Principal Investigator and informal approval, the documentation would be given an advanced release for procurement and/or fabrication. Any necessary changes would be recorded as drawing revisions and handled through normal release channels but without formal ECP change paper. The document to be released was transmitted to the Configuration Control activity with release instructions. Generally, the make-or-buy decision was made by prior agreement between the Purchasing Agent and the Project Supervisor and in the light of prototype experience. Because of schedule and cost factors, most release had to be for total quantity requirements even though the risk of future changes was a real threat. Configuration Control issued a Release Memo with prints to the scheduling, follow-up, and procurement activities or to manufacturing as appropriate. Control of release status was maintained by Configuration Control. If Quality Requirements (QR's) or Quality Control Instructions (QCI's) were required, they were generated and applied by the Quality and Manufacturing Engineering activities. As fabrication progressed, a Build Configuration List was issued for each deliverable unit and updated as required.

2.4.2.4.1 The Preliminary Design Review. This review was convened in Pre-Board session on March 4, 1970 at MSFC and was attended by CCSD in support of the P. I. The entire M507 Experiment was covered by specialty such as structures, mechanical, materials, fluid and thermal, electrical, test, reliability and quality, human factors, crew integration, and documentation. Although much of the final documentation had been completed by this time, the items reviewed were the Contract End Item Specification and the Experiment Integration Document. Both documents were very detailed and the majority of the Review Item Discrepancies (RID's) were attributable to errors or inconsistencies between the two documents. Several RID's required the furnishing of additional information by CCSD and a few were directed to safety aspects which were to be handled at a later date. The Formal Board met on March 26, 1970 and established final disposition on all outstanding RID's.

2.4.2.4.2 The Experiment Integration Test Requirements M507-Review. This review was held on June 24, 1970 with CCSD in attendance. It was established that no special handling or installation equipment would be required. Two changes did result from this review: a VOLTAGE ON pilot light was incorporated and the functional title VOLTAGE SELECTOR was added. CCSD made it known that the only piece of ground test equipment needed to indicate electrostatic operation would be an electrostatic voltmeter and probe capable of 50kv.

2.4.2.5 Operation, Maintenance, and Handling Procedure

A separate document for this specific purpose was not created. The operating procedure is clearly stated in the Contract End Item Specification and the workbench does not require servicing, maintenance, or calibration. Other applicable instructions are either simple and self-evident or require no special attention.

2.4.2.6 Training Requirements

Chrysler was not required to make any inputs on this subject. It was agreed at the outset that the Qualification Unit may be used for experiment hardware familiarization.

2.4.2.7 Experiment Hardware Support Requirements

This support was defined in the Contract End Item Specification which CCSD contributed.

2.4.2.8 Post-Delivery Support

This support would be required at a time too long after contract completion to be included in its scope.

2.4.2.9 Shipping Containers

The original concept was to package the table top in one container and the remainder of the Electrostatic Workbench in a second box. This was discarded in favor of a single container to save shipping weight and construction cost and also to eliminate the possibility of two containers getting separated during shipment or handling. Although there was no requirement to formally document the container design, it had to be reusable and generally meet the intent of MSFC-STD-343A for shipment of electronic equipment by commercial carrier.

All workbench subassemblies are enclosed in a sealed vapor barrier to maintain cleanliness. The table top is preattached to one container side by its three storage brackets. The ion shield is attached by its bracket and the power supply by its mounting base to a plywood panel in much the same manner as in operational configuration. This panel is cushioned by rubberized hair and attached to the container bottom. The Data Package is protected by a vapor proof bag and is attached to the inside of the container. Both unmated connectors are guarded by plastic connector protectors. The table cable is coiled, wrapped, and secured. All container sides are constructed of 1/4-inch plywood, reinforced with 1 by 2-inch stringers and the container assembly is by screws, resulting in a size approximately 16 by 28 by 28 inches. Two views of the container during packing of the Workbench are shown in Figures 15 and 16. The shipping weight is approximately 65 pounds.

2.4.2.10 Storage Container

The storage container concept developed as discussed in paragraph V.A.3.a and b became the three-bracket design.

2.4.2.11 Spares Requirement.

It became evident as the workbench preliminary design evolved that the type of construction required to cope with the high voltage and induced environments would not be compatible with any degree of component replacement. This became a design goal: to create the design to minimize or eliminate the need for spares. The only spare to be provided is the Back-Up Unit complete assembly. One option is available, however: the Back-Up Unit can be substituted for the Flight Unit or the table top and electronic subassemblies can be substituted individually.

Figure 15. Shipping Container - Vapor Barrier Removed

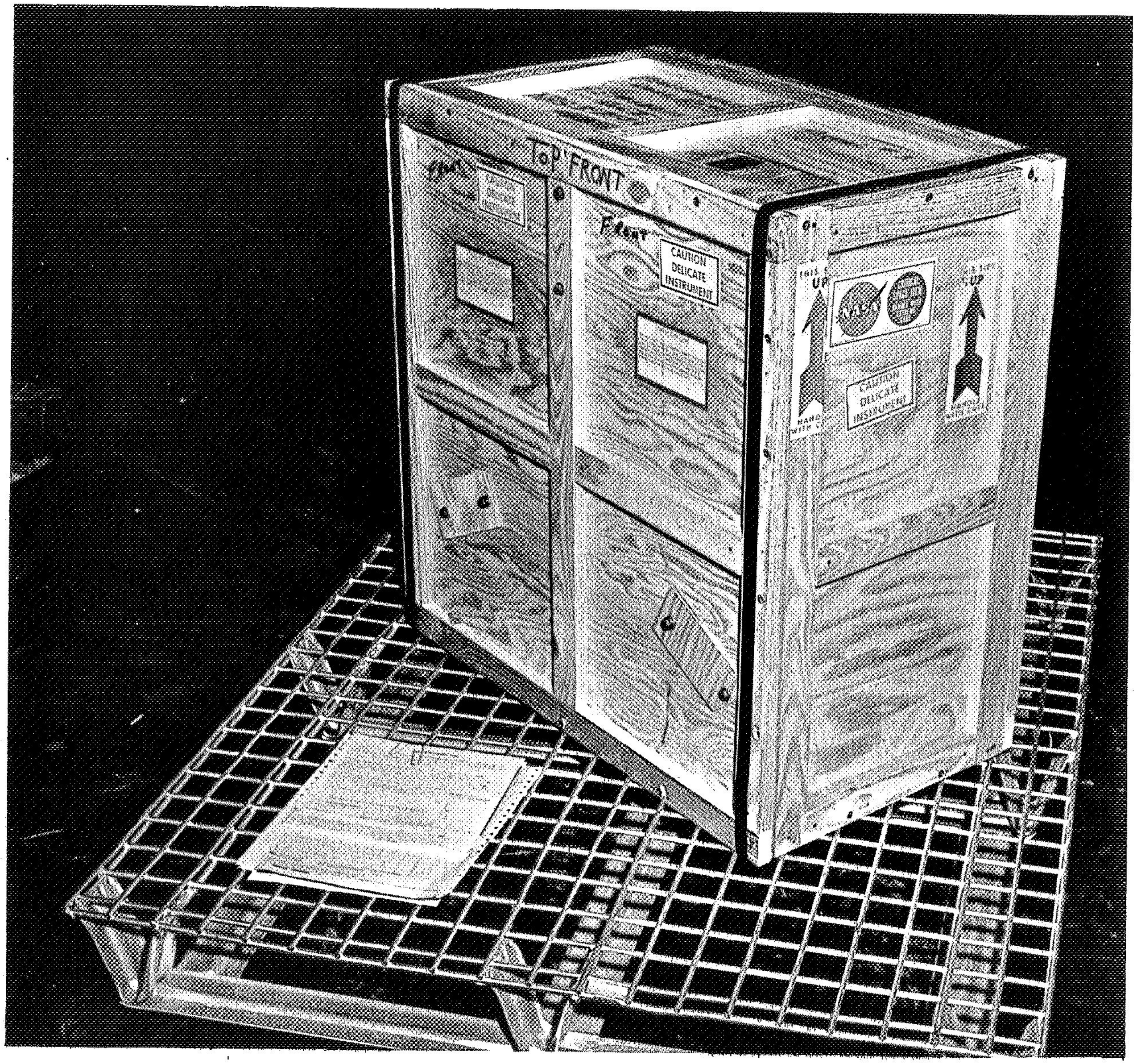


Figure 16. Shipping Container Exterior

2.4.3 Aerodynamic Workbench

2.4.3.1 Engineering Support

The original vellums of all drawings and parts lists created for this design were shipped to MSFC in May 1970. Since that time, several EO's have been written by MSFC and comments on them were made. During build-up of the Qualification Unit at MSFC, a few questions have arisen on material call-outs which were answered by CCSD. Comments were also made on the Aerodynamic Workbench Qualification Test Specification drafted by MSFC.

2.4.3.2 Formal Reviews

Support was furnished to the Principal Investigator at the PDR as stated in paragraph 2.4.2.4. The principal effect on the Aerodynamic Workbench design emerging from this review was the requirement for a protective exit screen and the electrically bondable interfaces.

There were no special installation or handling tools identified at the Experiment Integration Test Requirements Review. Although it is easy to tell by observation that the motor and fan are working, the effect of the motor speed control is not necessarily obvious. It was decided that a strobotac would be proposed as ground test equipment so that the specified speeds (compensated for sea level conditions) could be checked.

2.4.3.3 Operating, Maintenance, and Handling Procedures.

The operating procedure is stated in the Contract End Item Specification, the same as for the Electrostatic Workbench. The design is such that servicing, maintenance, and calibration are not required. There are no provisions for adjustment once the fabrication and assembly is completed. Consultation and the furnishing of information during the writing and revision of the CEI Specification were the contributions made by CCSD on this subject.

2.4.3.4 Post Delivery Support

This support would be required too long after contract completion to be included in its scope.

2.4.3.5 Shipping Containers

Several preliminary concept sketches were made and submitted to MSFC. The P. I. decided to utilize the packaging manpower available at MSFC, and Chrysler was not further involved.

DISTRIBUTION

Chrysler Corporation Space Division

R. J. Bork	Electro-Mechanical Design	1
D. N. Buell	Advanced Engineering	1
E. J. Dofter	Reliability Engineering	1
N. R. Elchison	Manufacturing	1
C. C. Gage	Product Engineering	1
W. H. Juengling	Electrical and Electronic Engineering	1
T. O. Knight	Materials Engineering	1
J. F. Patrick	Quality Control	1
P. E. Theobald	Project Supervisor	1
C. E. Thomas	Electrical Systems	1
A. C. Stevens	Electro-Mechanical Design	1
V. J. Vehko	Director of Engineering	1
Technical Files		10
Technical Writing and Editing Group		1

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MSFC/A&TS-MS-IL	1
MSFC/A&TS-MS-IP	2
MSFC/A&TS-PR-MBA	1
MSFC/A&TS-TU	1
MSFC/S&E-ME-MX	10
MSFC/S&E-R-F	1
NASA/MICH/DU	1

APPENDIX A

INSPECTION PLAN

INSPECTION PLAN
FOR THE
ELECTROSTATIC
GRAVITY SUBSTITUTE WORKBENCH

CONTRACT NAS8-21385 PHASE III

CHRYSLER CORPORATION

SPACE DIVISION

MICHOUD ASSEMBLY FACILITY

Date Prepared:

December 5, 1969

REV. 3-6-70

INTRODUCTION

This Inspection Plan will be utilized for Contract NAS8-21385 PHASE III for the fabrication and testing of a qualification unit, the fabrication delivery of a flight unit, and a flight back-up Electrostatic Gravity Substitute Workbench.

This Inspection Plan has been developed in response to the requirements of NASA Quality Publication NPC 200-3 and submitted to the contracting officer in accordance with paragraph 2.2 of NPC 200-3.

The plan will assure Chrysler Corporation Space Division has an inspection system that satisfies the requirements of NPC 200-3, "Inspection System Provisions for Suppliers of Space Materials, Parts, Components, and Services."

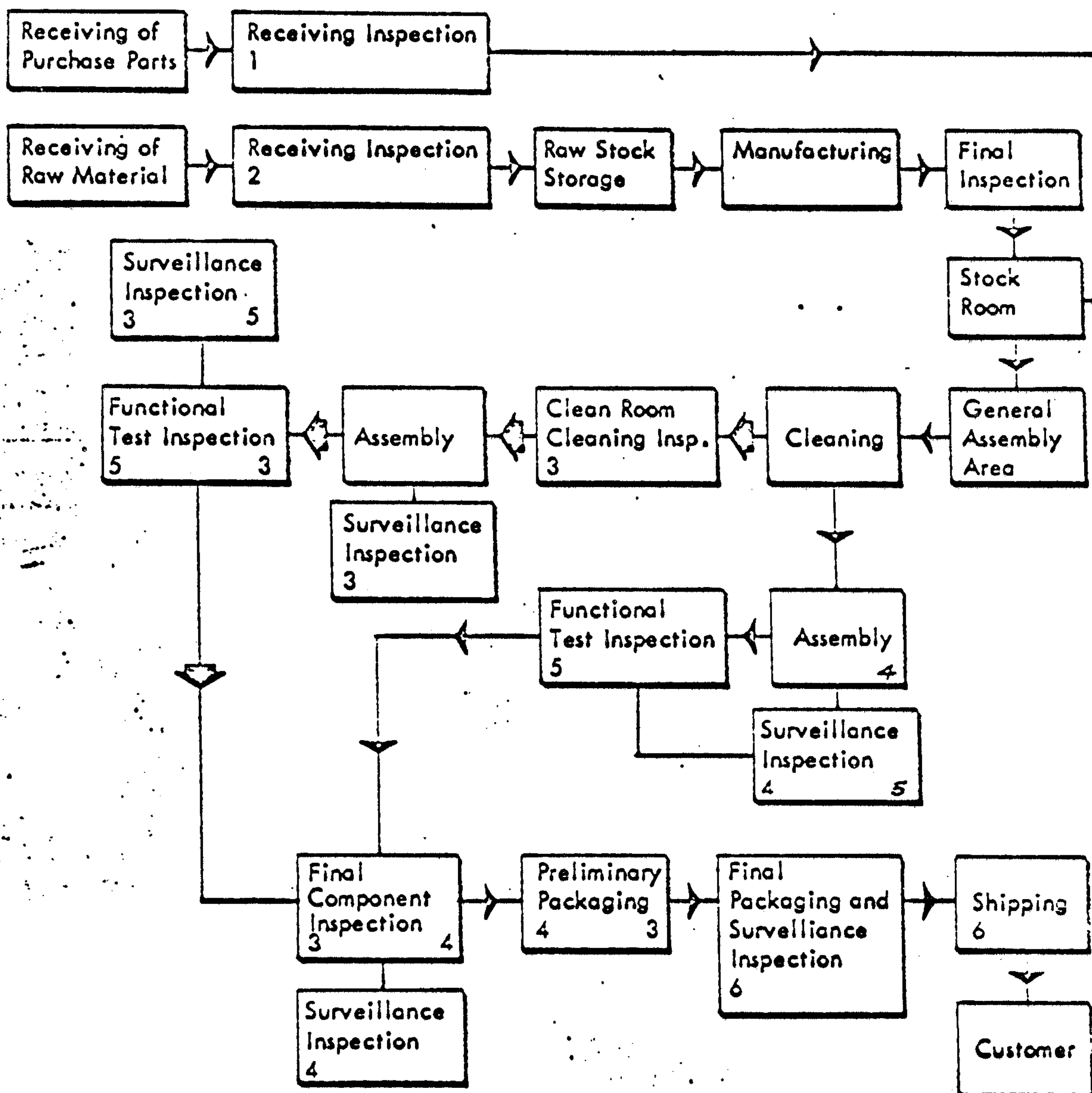
Changes to the scope of work or quality requirements of this plan will require revisions to the plan and resubmission of the changes for review two weeks prior to use.

J. F. Patrick

J. F. Patrick, Manager
Quality Control

March 6, 1970

PRODUCT FLOW CHART



KEY - INSPECTION STATIONS

1. Inspection Department
2. Raw Stock Area
3. Clean Room
4. General Assembly Area
5. Test Area
6. Shipping

A-3

1.0 PURCHASE ORDER REVIEW

1.1 Prior to issuance of a purchase order, Quality Engineering personnel will review the drawings and specifications to determine the necessity of adding specific quality requirements to the purchase order.

1.2 After completion of this review, the purchase order will be forwarded to the Purchasing Department for Procurement action.

1.3 Procurement packages are subject to review by NASA prior to the release of the package for procurement action.

2.0 SOURCE INSPECTION

2.1 When Government source inspection is required by NASA, purchase orders will include the following statement:

"All work on this order is subject to inspection and test by the Government at all times and places. The Government representative who has been delegated NASA quality assurance functions on this procurement shall be notified immediately upon receipt of this order."

2.2 All other orders will include the following statement:

"The Government reserves the right to inspect any or all of the work included in this order at the supplier's plant."

2.3 When Chrysler source inspection is required, purchase orders will include the following SD-10 clause:

Clause SD-10

"Chrysler source inspection is required prior to shipment to our plant. Supplier shall notify CCSD Quality Engineering at least five (5) days prior to final inspection or test. Notwithstanding the Chrysler source inspection specified herein, Chrysler reserves the right to return for credit any articles furnished hereunder which at any time are found defective in material or workmanship or otherwise not in conformity with the requirements as specified in the Purchase Order and applicable specifications."

2.4 If Chrysler source inspection has been performed, material shipped to Chrysler will be accompanied by a Chrysler Corporation Space Division Acceptance Report, Form No. 646-61228. (see Forms Section for exhibit).

3.0 PERSONNEL, EQUIPMENT AND MATERIAL CERTIFICATION

3.1 In accordance with the requirements of the drawings and specifications, suppliers furnishing material which requires certification of the material or of their personnel and/or equipment will be required to furnish such certification to Chrysler when supplying such material.

4.0 RECEIVING INSPECTION

4.1 Receiving inspection will be performed in accordance with published Quality Control Instructions, Form No. 642-61209, which have been prepared by the Quality Engineering Branch. (see Forms Section for exhibit).

4.2 Receiving inspection personnel will document the results of their inspection on an "Incoming Material Report," Form No. 646-61326. (see Forms Section for exhibit). This information will consist of the following:

(1) Date received

(2) Part number

(3) Revision Letter

(4) Serial number of this item if serialized

(5) Purchase order number under which the material was procured

(6) Invoice Shipper number

(7) Company work order number

(8) Part name

(9) Vendor's name

(10) Vendor's code number

(11) If the material is GFP or R&D material

(12) If Government and/or Chrysler source inspection was performed

(13) Requisition number

(14) Class code of material

(15) Where the material is to be delivered

(16) Register number

(17) Badge number of recipient

(18) Quantity received

(19) Unit of measure

(20) Date the material was delivered to inspection

(21) The type of inspection performed; i.e., visual and dimensional, material test, electrical, mechanical, age control, and/or the clean level of the material

(22) The QCI used to inspect the material

(23) The QR No. received from the supplier

(24) The QCI characteristics checked

(25) The AQL used if sampling was approved and performed

(26) Total quantity inspected

(27) If defective units were detected, whether they were Chrysler or supplier responsibility

(28) The code of the defect detected. (This is obtained from the Quality Assurance and Reliability Data Control Code Index.)

(29) The quantity of material destroyed in material test, if performed

(30) Total quantity defective

(31) Total quantity accepted

(32) The final inspector's acceptance stamp. In the event the material has been rejected and is to be returned to the supplier, a rejection stamp is applied to the Incoming Material Report.

4.3 Receiving inspection will inspect to ensure:

(1) That procured materials and articles indicate evidence of inspections and tests performed by the suppliers in accordance with purchase requirements and are accompanied with the required inspection and test data.

(2) That materials and articles or accompanying records exhibit evidence of Chrysler and/or Government source inspection, as required.

(3) That supplier inspection and test data is acceptable by conducting visual inspections of selected characteristics as defined by the appropriate Quality Control Instruction.

(4) That identification requirements have been met and maintained.

(5) That all required data and records are complete and correct.

(6) That articles and materials having definite characteristics of quality degradation or drift with age and/or use indicate the date and test time or cyle at which the useful life was initiated, and the date of expiration.

(7) That the quality status of articles and materials is maintained during receiving inspection. This will include the physical separation and identification of articles and materials according to the following categories:

a. Items awaiting inspection

b. Conforming items

c. Nonconforming items

(8) That articles and materials and their records clearly indicate their acceptance or nonconformance status when released from receiving inspection.

(9) That articles and materials to be released are adequately controlled and protected for subsequent handling, storage or use.

4.4 All nonconformances detected during receiving inspection will be recorded on an "Inspection Squawk Sheet," Form No. 616-61480. (see Forms Section for exhibit.) In addition to the description of the nonconformances, the following information will be recorded on the Inspection Squawk Sheet as follows:

(1) Defective part number

(2) Serial number, as required

(3) Date of initiation and initials of the inspector

(4) Quantity containing the defect

(5) Defect code

(6) Responsibility code

(7) Recommended disposition action (this is recorded by the Inspection supervisor)

(8) If the defect was corrected, by whom

(9) Quantity accepted

(10) Quantity rejected

(11) Inspection station number

(12) The date the nonconformance was reworked and accepted and the inspection acceptance stamp approving the acceptance

NOTE: In the event the nonconformance cannot be cleared by rework; i.e., reworked to the drawing and specification requirements, or the defective item is not obvious scrap, the Inspection supervisor in conjunction with a Chrysler design engineer will provide a recommended disposition of "repair," "use as is," or "scrap."

The Squawk Sheet will then be processed to the NASA-MSFC Technical Representative for final disposition.

4.5 Upon completion of receiving inspection, information concerning supplier-responsible nonconformances will be forwarded to the supplier along with a Supplier Corrective Action Request, Form No. 84-743-62437, to ensure that the supplier takes prompt remedial and preventive action to preclude recurrence of the nonconformances. (see Forms Section for exhibit)

4.6 Upon successful completion of Receiving Inspection, the Incoming Material Report and the articles will be stamped with the CCSD Acceptance stamp illustrated below:

CCSD
IN-P
11

4.7 Raw material will be routed to the raw material crib and finished items will be routed to the stock room or the using area, as required, on a Material Forwarded Tag, Form No. 756-61240. (see Forms Section for exhibit) The following information will re recorded on the Material Forwarded Tag:

(1) Date

(2) Part number

(3) IMR number and revision number, if applicable

(4) Part name

(5) P. O. number, and revision, if any

(6) Area from which the material is being moved

(7) Area to which the material is being moved

(8) Quantity inspected

(9) Quantity rejected

(10) Quantity accepted

(11) Register (tally) number

(12) Material handler's badge number and initials

4.8 Nonconforming articles and material which have been rejected or which have been destroyed by materials testing will be disposed of by initiation of a Scrap Tag, Form No. 739-61570. (see Forms Section for exhibit)

The following will be recorded on the Scrap Tag:

(1) Part name

(2) Part number and revision, if any

(3) Date of initiation

(4) Nature of defect

(5) Routing

(6) Lot number

(7) Effectivity

(8) Configuration

(9) Quantity

(10) Serial number/s, if any

(11) Defect code

(12) Unit of measure

(13) Department found

(14) Cause code

(15) Responsibility code

(16) Class code

(17) Responsible supervisor's signature

(18) Material Department representative signature

(19) Inspector's signature accompanied by a CCSD Reject Stamp as illustred here:

The Scrap Tag and the material will then be routed to the central reject crib and disposed of by the Material Department.

5.0 ASSEMBLY AND TEST CONTROL

5.1 Assembly and test control will be performed by Quality Control inspection personnel utilizing:

(1) Assembly drawings

(2) Test specifications

(3) Quality Control Instructions

5.2 The control exercised by the inspection personnel will be performed by monitoring the work accomplished by the Engineering assembly and test personnel.

5.3 As each assembly and test operation is performed, the inspector will review the Quality Control Instruction and indicate acceptance or rejection on the Quality Control Instruction by the appropriate stamp.

5.4 The Quality Control Instructions will essentially outline in sequential fashion the operations to be performed by the inspector. These written instructions, prepared by Quality Engineering, will define:

(1) The details of the inspection

(2) The detailed operations to be witnessed

(3) The criteria for determining quality conformance or rejection of the articles

(4) Identification of the article to be inspected or tested (e. g., part number, system involved, and nomenclature)

(5) Objectives of the inspection or test

(6) The test methods and the test equipment to be witnessed during the surveillance operation

(7) The conditions which should exist at each examination point

(8) The levels or limits of input or stresses to be applied

(9) In the case of visual inspection, the optimum acceptable condition will be defined

5.5 Upon successful accomplishment of the inspection and test, the inspector will indicate final acceptance of the article on the Quality Control Instruction with his acceptance stamp. (see stamp illustration in paragraph 4.6) The QCI will then be forwarded to the Engineering Department Configuration Control Center to provide for the as-built configuration accounting.

5.6 Nonconformances detected during the assembly and test operation will be recorded on the Inspection Squawk Sheet. Nonconformances which can be reworked to the drawing will be reworked and cleared by the inspector on the Squawk Sheet.

5.7 Nonconformances which cannot be reworked because of a disposition of "repair" or "use as is" will be presented to the NASA-MSFC Technical Representative for final disposition and acceptance. The Technical Representative's disposition will be recorded on the Squawk Sheet and shall constitute final disposition by NASA.

5.8 Rejected articles will be disposed of by means of the Scrap Tag and handled by the Central Reject Crib. The tag and the articles will be identified with a rejection stamp. (see stamp illustration in para. 4.8)

6.0 PERSONNEL CERTIFICATION

6.1 The need for and/or the degree of personnel certification necessary shall be as determined by the NASA-MSFC Technical Representative and shall constitute final adjudication in this area.

7.0 PACKAGING AND SHIPPING INSPECTION

7.1 Packaging and shipping inspection will be performed, in accordance with Quality Control Instuctions, and will verify that:

(1) The item description (Part number, Rev.) and quantity on the packing slip agree with the items to be packaged

(2) Proper identification is used on the intermediate container

(3) Intermediate containers are packed in outer containers in such a way as to be a solid pack

(4) Packing slip, test data, etc., as required are in the package

(5) Packaging is in accordance with the packaging specification sheet

8.0 METROLOGY CONTROL

8.1 All inspection, measuring, and test equipment will be calibrated at scheduled intervals against certified standards which have known, valid relationships to natinnal standards. This calibration will be performed by the Metrology Section.

8.2 Records will be maintained indicating the date of the last calibration and the due date of the next calibration. (see Forms Section for exhibit)

8.3 The due date or other identification attesting to the due date of the next calibration will be displayed on each item of inspection, measuring, and test equipment. (see decal in Forms Section)

8.4 Inspection, measuring, and test equipment which pass their due date for calibration will be tagged with a red tag which states:

"DO NOT USE THIS EQUIPMENT UNTIL RECALIBRATED"

(see Forms Section for exhibit)

This equipment will be returned to the Metrology Laboratory for recalibration by the user.

9.0 CONFIGURATION CONTROL AND ACCOUNTING

9.1 The baseline configuration established as the result of the Critical Design Review, along with the completion of action items resulting from this review, and released for manufacturing will be used by quality control personnel to determine the compatibility of the deliverable end item with this baseline configuration.

9.2 Upon successful completion of acceptance and complete compatibility of the end item as built with the engineering definition, the as-built configuration record will be forwarded to the Engineering Release Center for configuration accounting and records purposes.

9.3 Configuration Inspection (CI) will cover the qualification unit after completion of the qualification tests. Detailed comparisons of inspection records and released documentation will be conducted and test results will be examined against requirements. Completeness of the acceptance data package will be established.

9.4 Subsequently, the flight unit and the flight back-up unit will be submitted to MSFC for acceptance, accompanied by complete inspection records and acceptance test data.

9.5 Successful completion of this review will result in the signoff of the MSFC Form 71 and the generation of the Certificate of Flight Worthiness document.

10.0 MONTHLY INSPECTION REPORT

10.1 Monthly, an inspection report will be submitted by inspection to be incorporated into an overall management report which will contain as a minimum:

(1) Schedule status

(2) Mass properties status

(3) Quality and reliability status

(4) A brief account of current test activity

NO.	REV.	DIST. CODE	SPACE DIVISION CHRYSLER CORPORATION	PART NO.	SHEET OF
PREPARED BY		DATE		PART NAME	
APPROVED		DATE	QUALITY CONTROL INSTRUCTIONS		EFFECTIVITY

ITEM NO.	CHARACTERISTIC	AQL	INSP. BUY-OFF	EQUIPMENT

REV. NO.	SH NO.	DESCRIPTION	AUTHORITY	BY	DATE

CHRYSLER CORPORATION SPACE DIVISION

No 20441

ACCEPTANCE REPORT

SUPPLIER	PART NAME	PART NUMBER	CHG. LTR.	SERIAL NO.

CONTRACT, P.O. OR I.P.R. NO.	QUANTITY	SHIPPED TO:

SPECIFIC INSPECTION CRITERIA

QUALITY REQUIREMENT

QUALITY CONTROL INSTRUCTION

MATERIAL LAB. REPORT

SUPPLIER'S REQUEST FOR MATERIAL REVIEW ACTION NO.

ENGINEERING CHANGES INCORPORATED IN ADDITION TO ABOVE CHANGE LETTER:

REMARKS:

INSPECTION OF THE ITEM OR ITEMS LISTED [illegible]IN HAS BEEN MADE BY ME OR UNDER M[illegible] SUPERVISION AND THEY ARE HEREBY ACCEPTED BY CHRYSLER SPACE DIVISION SUBJECT TO SELLERS WARRANTIES AND THE EXCEPTIONS NOTED HEREIN.	GOV'T SOURCE INSPECTION YES ☐ NO ☐	SIGNATURE, QC REPRESENTATIVE DATE	CCSD SOURCE INSPECTION STAMP

SUPPLIER

846-61326 MAR. 1965.

INCOMING MATERIAL REPORT

CHRYSLER CORPORATION SPACE DIVISION

LOT NO. A 162921

DATE RECEIVED (Rec. Dept.) 42					
PART NO. 22	REV. LTR.	SERIAL NO.	P. O. NO. 29A	INV. SHIPPER 29	CWO NO.
PART NAME			VENDOR NAME		VENDOR CODE 35

GFE	SOURCE INSP. CCSD	SOURCE INSP. GOVT.	REQUISITION NO.	CLASS CODE	DEL. TO	REGISTER NO.	BADGE NO.	QUANT. REC.	UNIT OF M.	DATE TO INSP.
R & D				45				50		

INSPECT AREA	QCI - NO.	QR. NO.	QCI CHARACTERISTIC CHECKED	AQL	TOTAL QUANTITY INSPECTED	QTY. DEFECTIVE IN TOTAL SAMPLE		DEFECT CODE		INSP. STAMP
						CCSD	VENDOR			
V & D 52				55	60	63	66	69 75	72 78	
MAT. 52				55	60	63	66	69 75	72 78	
ELECT. 52				55	60	63	66	69 75	72 78	
MECH. 52				55	60	63	66	69 75	72 78	
LAB. 52				55	60	63	66	69 75	72 78	
AGE CONT. 52				55	60	63	66	69 75	72 78	
CLEAN LEVEL 52				55	60	63	66	69 75	72 78	
PARTS REQUIRING STAMPING	QCI INDEX DATE	OTHER QR	REMARKS (Insp.)				QTY. DEST. IN TEST	QTY. DEFECT.	QTY. ACC.	FINAL STAMP

EO—	EO—

REMARKS (Receiving)

COPY 1 — RECEIVING INSPECTION

INSPECTION SQUAWK SHEET

SPACE DIVISION **CHRYSLER** CORPORATION

SHEET ___ OF ___
___ D ITEM
R & D ITEM
GFE

NO.	ASSEMBLY NO.		REV.
STAGE NO	ASSY. NAME	SERIAL NO.	

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND

ORIGIN / DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION: DEF. CODE / RESP. CODE	DISPOSITION: RECOMM. ACTION / CORRECTED BY	DISPOSITION: QTY. ACCEPT / QTY REJECT	FINAL: DATE & INSPECTION STAMP

84-745 6243 JAN.65

SPACE DIVISION CHRYSLER CORPORATION

SUPPLIER CORRECTIVE ACTION REPORT

No: Nº 302158

Date:

TO

The items described on the attached Defective Material Notice do not conform to requirements of applicable specifications and drawings. It is requested that you determine assignable cause and take action to prevent recurrence of this discrepancy. Complete the blocks below and return TOP three copies to the address below. This information will be added to your performance record.

Defective Material Notice Number	Purchase Order Number	Part Number	Rev.

Analysis of Discrepancy and Assignable Cause

Corrective Action Taken

Effective Date ____________ Effective Purchase Order Number ____________

Retain fourth copy and
Return Copies 1,2, and 3 to:

Chrysler Corporation Space Division
P.O. Box 29200
w Orleans, Louisiana 70129

ATT: Mr.

Vendor Quality & Cost Analysis
Purchasing Department

Supplier Quality Representative's Signature

Title

Date

A-21

756-61240 Rev. Mar. 65.
Chrysler Corporation
Space Division

MATERIAL FORWARDED

001751

PART NUMBER | REV. | SERIAL NO. | LOT NO. | DATE

PART NAME | SHOP ORDER NO. | ROUTING

QTY. | UNIT/M | N/A | CWO NO. | NON-STD ☐ UP DATE ☐

EO'S, ECP'S

REMARKS:

LAST OPER.

DMN OR SCRAP NO.

From Dept. No.

TO DEPT. NO.

QTY. INSP. | QTY. REJ. | QTY. ACC. | PAY PT. NO. | INSP. DATE/MATL. CON. BADGE | INSP. STAMP

COMPT. STANDARD | MARK "X" IF PAY POINT CALLED OUT ☐ | DEPT. PAID | INSPECTOR'S SIGNATURE

SCHEDULING COPY

739-61570 JAN. 65
CHRYSLER CORP.

SCRAP TAG

DATE

42844

PART NAME

PART NO.

REV.

ROUTING

LOT NO.

EFFECTIVITY

NATURE OF DEFECT

CONFIG.

QTY.	WORK ORDER	S/O	SERIAL NO.

Defect Code:

UNIT OF MEAS.

DEPT. FOUND

CAUSE CODE

RESP. CODE

RESP. SUPERVISOR SIGNATURE

DEFECT. OPER.

LAST OPER.

INV. CODE

CLASS CODE

MATERIAL

LABOR

BURDEN

TOTAL

MATERIAL REP.

INSPECTION REP.

MOVE FROM:

MOVE TO:

PRODUCTION CONTROL COPY

CHRYSLER CORPORATION
Space Division
GAGE RECORD

DEPARTMENT	IDENT. NO.	LOCATION	SCHED.	PERIOD	WEEK	WEEK	WEEK	WEEK

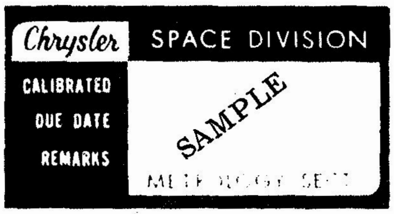
TOOL OR GAGE NO.	DESCRIPTION
DATE RECEIVED	
DISTRIBUTOR	MANUFACTURER

INITIAL INSPECTION					INSP. STAMP
DIM. OR MEAS.	TOLERANCE	ACTUAL	DISPOSITION	REMARKS	

SURVEILLANCE RECORD												
DUE DATE	DIMENSION OR MEASUREMENT					* CONDITION OR ADJ. MADE	INSP. TIME	DISP.	DATE INS'D.	NEXT INSP.	INSP. STAMP

* WHEN THIS SPACE IS INADEQUATE A SEPARATE REPORT WILL BE MADE


CHRYSLER CORPORATION
METROLOGY SECTION
DO NOT USE
THIS EQUIPMENT
UNTIL
CALIBRATED
667-61497, JAN, 65


Chrysler
SPACE DIVISION
CALIBRATED
DUE DATE
REMARKS
SAMPLE

APPENDIX B

FAILURE MODE EFFECTS, CRITICALITY, ANALYSIS

RELIABILITY REPORT

9 April 1970

ELECTROSTATIC WORKBENCH ELECTRICAL SUBSYSTEM

POWER SUPPLY FMEA

A preliminary failure modes and effects analysis on the power supply of the electrostatic workbench subsystem is detailed in this document. This analysis provides additional information concerning the failure effects on the M507 experiment and methods of failure detection.

The power supply is divided into three sections as shown in Figure 1. The inverter section converts 28 volts DC to 20KC. The low voltage section converts 20KC to -300 volts DC, and the high voltage section converts 20KC to 40,000 volts DC.

In the electrostatic experiment, -300 volts is applied as a bias voltage to the electrostatic table top, while a step (10KV, 20KV, 30KV, 40KV) voltage is applied to the ion source.

Reliability block diagrams and the FMEA of the three power supply sections are in Parts I, II and III. The components in the analysis are numbered as shown on Drawing 95M12026, 40KV/300V Power Supply.

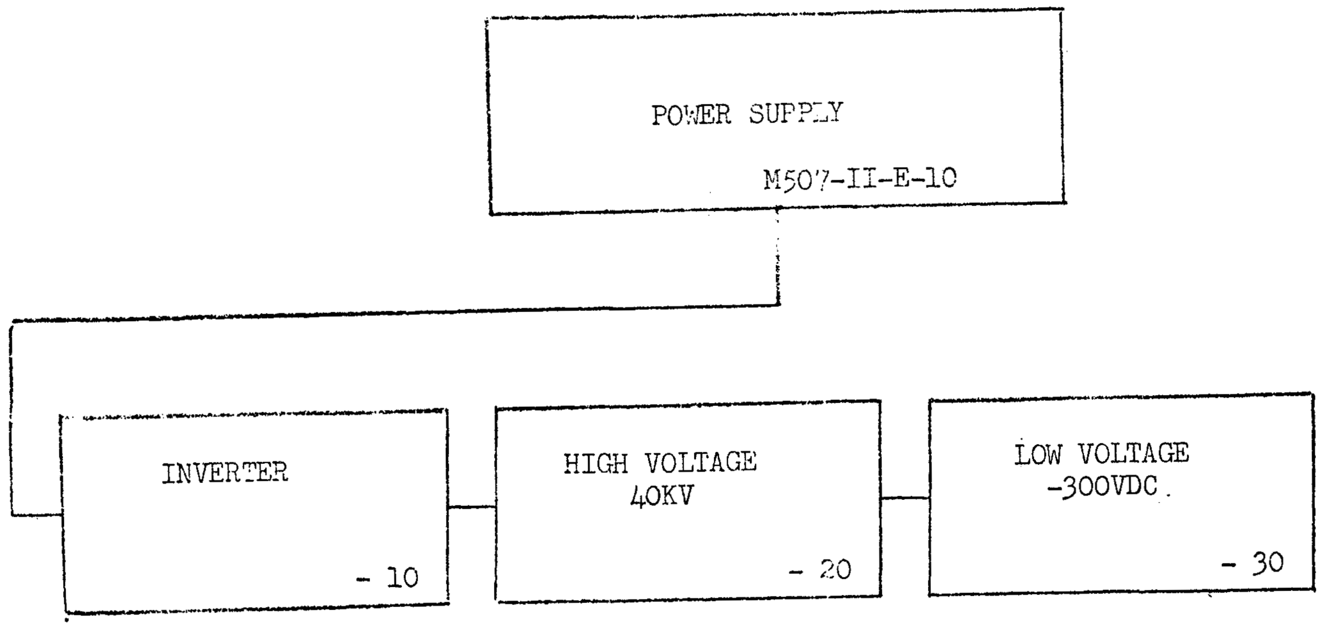


FIGURE 1. ELECTROSTATIC WORKBENCH ELECTRICAL

POWER SUPPLY

RELIABILITY BLOCK DIAGRAM

PART I

ELECTROSTATIC WORKBENCH ELECTRIAL SUBSYSTEM

POWER SUPPLY INVERTER

FMEA

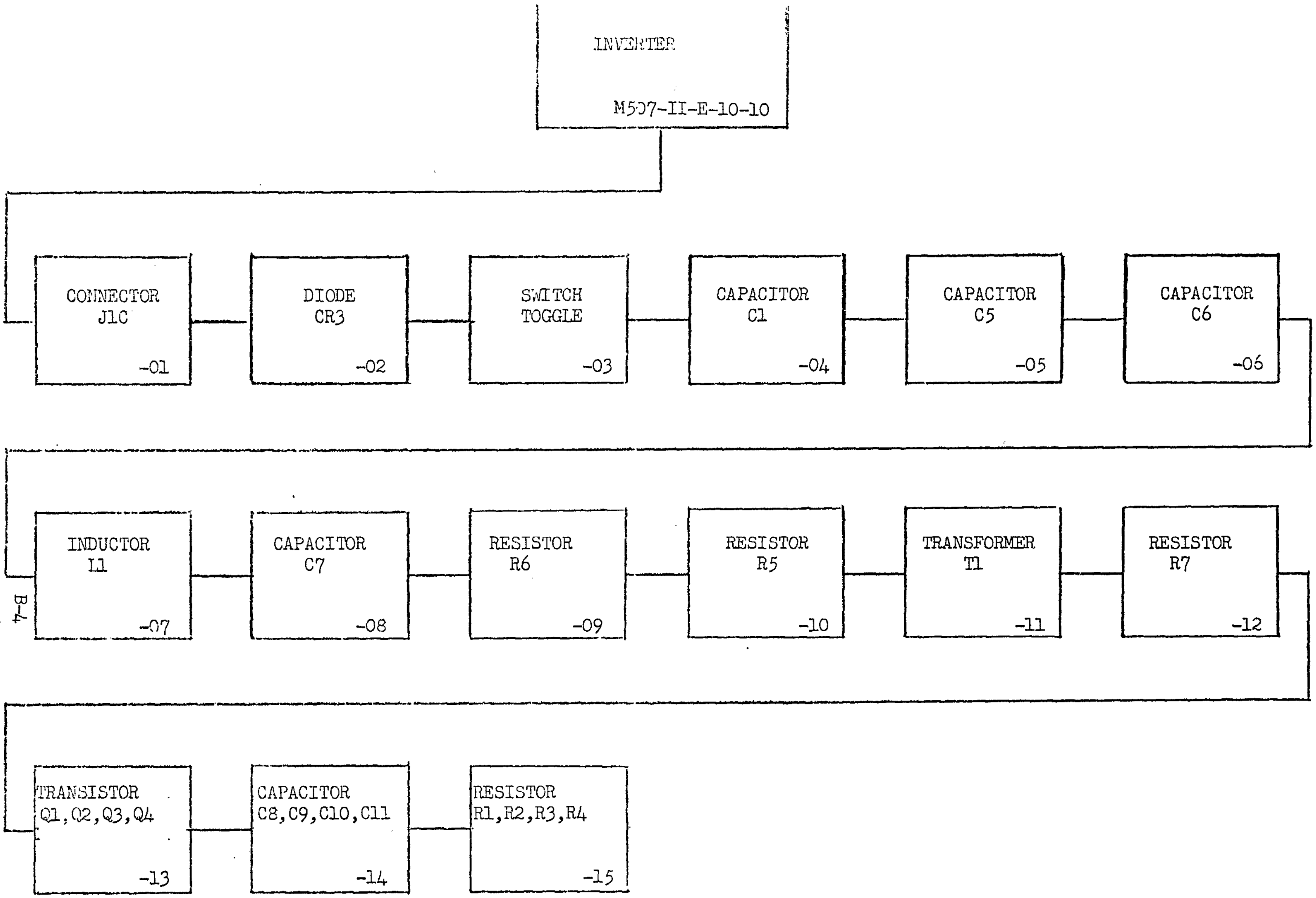


FIGURE 2. ELECTROSTATIC WORKBENCH ELECTRICAL POWER SUPPLY INVERTER RELIABILITY BLOCK DIAGRAM.

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
ELECTROSTATIC POWER SUPPLY INVERTER M507-II-E-10-10	1. Loss of output to +40KV and -300V DC.	1. <u>No Loss of M507 Experiment</u>. Loss of electrostatic portion. Loss of capability to create an electric field and to charge sample object used in experiment.	Sample object will not be attracted to the electrostatic table top. "Voltage on" (pilot light) indicator on the electrostatic power supply will be extinguished.
CONNECTOR J1C -01	1. Open	1. <u>No Loss of M507 Experiment</u>. Loss of electrostatic portion and field as above.	No attraction and no pilot light indication as above.
	2. Ground	2. <u>No Loss of M507 Experiment</u>. Loss of electrostatic portion and field as above.	No attraction and no pilot light indication as above.
DIODE CR3 -02	1. Open	1. <u>No Loss of M507 Experiment</u>. Loss of Electrostatic field.	No attraction. No pilot light indication.
	2. Short	2. <u>No Loss of M507 Experiment.</u> 10% decrease in high and low voltage.	None
SWITCH S1A -03	1. Open	1. <u>No Loss of M507 Experiment</u>. Loss of Electrostatic field.	No attraction. No pilot light indication.
	2. Short	2. <u>No Loss of M507 Experiment</u>. No Change	None

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
CAPACITOR C1	1. Short	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
-04	2. Open	2. No Loss of M507 Experiment. No Change	None
CAPACITOR C5	1. Short	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
-05	2. Open	2. No Loss of M507 Experiment. No Change	None
CAPACITOR C6	1. Short	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
-06	2. Open	2. No Loss of M507 Experiment. No Change	None
INDUCTOR L1	1. Short turns.	1. No Loss of M507 Experiment. No Change	None
-07	2. Open	2. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
CAPACITOR C7	1. Short	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
-08	2. Open	2. No Loss of M507 Experiment. No Change	None

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
RESISTOR R6 -09	1. Open	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
	2. Short	2. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
RESISTOR R5 -10	1. Open	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
	2. Short	2. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
TRANSFORMER T1 -11	1. Open (Any Winding)	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
	2. Short (Turn to Turn)	2. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
RESISTOR R7 -12	1. Open	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
	2. Short	2. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
TRANSISTOR Q1, Q2, Q3, Q4 -13	1. Open	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
	2. Short	2. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
CAPACITOR C8, C9, C10, C11 -14	1. Short	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
	2. Open	2. No Loss of M507 Experiment. Decrease of -300V. and 40 KV.	No attraction. Reduced holding power.
RESISTOR R1, R2, R3, R4 -15	1. Open	1. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.
	2. Short	2. No Loss of M507 Experiment. Loss of electrostatic field.	No attraction. No pilot light indication.

PART II

ELECTROSTATIC WORKBENCH ELECTRICAL SUBSYSTEM

POWER SUPPLY, HIGH VOLTAGE

FMEA

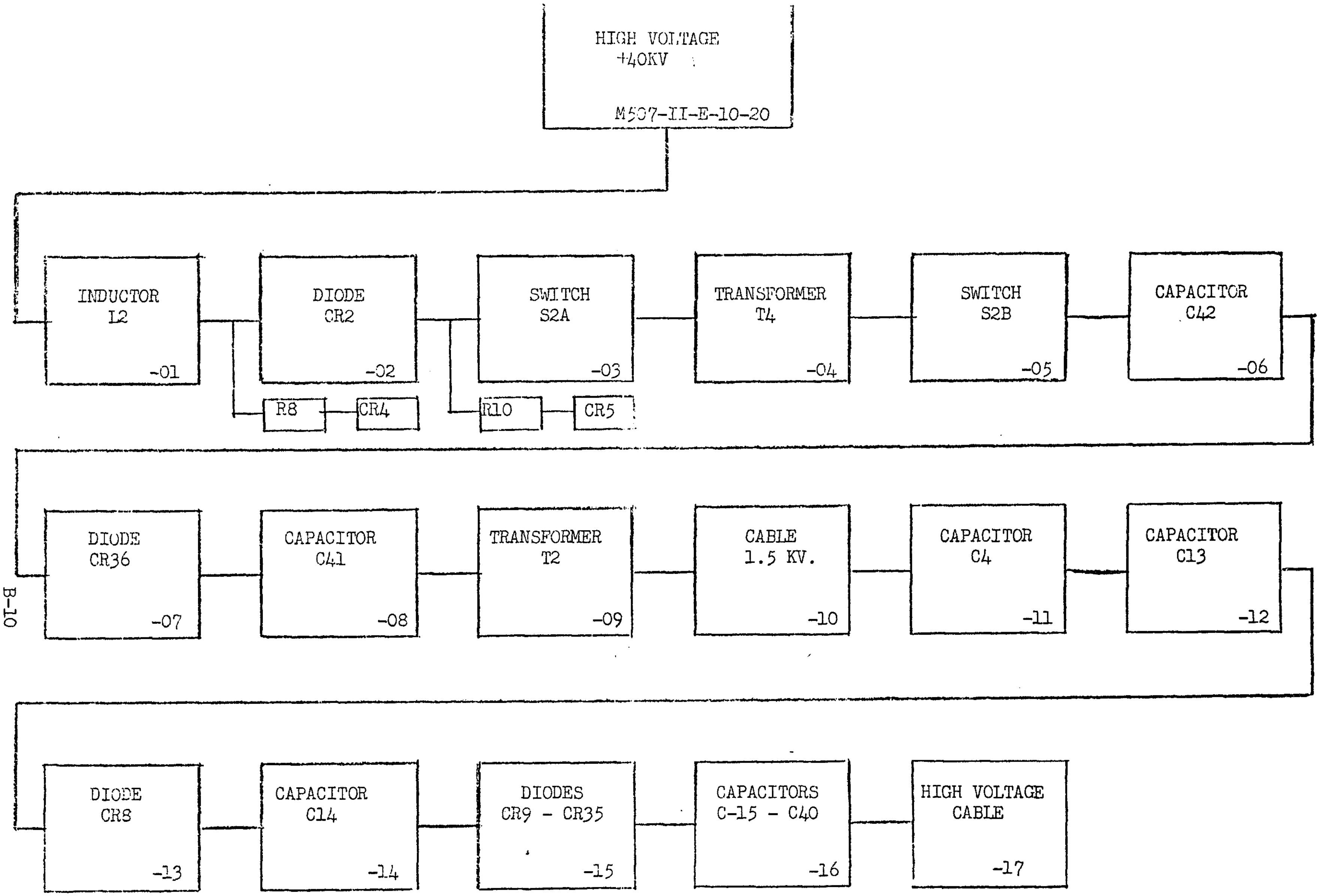


FIGURE 3 . ELECTROSTATIC WORKBENCH ELECTRICAL POWER SUPPLY
HIGH VOLTAGE RELIABILITY BLOCK DIAGRAM

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
ELECTROSTATIC POWER SUPPLY HIGH VOLTAGE M507-II-E-10-20	1. Loss of output to ion source.	1. No Loss of M507 Experiment. Loss of high voltage electrostatic field. Loss of capability to create a high voltage (positive) electric field and to charge sample object by means of high voltage.	Sample object will not be attracted to the electrostatic table top due to the high voltage field. "Voltage on" (pilot light) indicator on the power supply will be on. Sample object will adhere to table top due to low voltage.
INDUCTOR L2	1. Short(Turn To Turn)	1. No Loss of M507 Experiment. No Change	None
-01	2. Open	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
DIODE CR4	1. Open	1. No Loss of M507 Experiment. No Change	None
	2. Short	2. No Loss of M507 Experiment. Loss of 10% of 40KV.	None
Resistor R8	1. Open	1. No Loss of M507 Experiment. Increased 40KV.	None
	2. Short	2. No Loss of M507 Experiment. No Change	None

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
DIODE CR2 -02	1. Open	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Short	2. No Loss of M507 Experiment. Loss of 10% of 40KV.	None
DIODE CR5	1. Open	1. No Loss of M507 Experiment. No Change	None
	2. Short	2. No Loss of M507 Experiment. Loss of 10% of 40KV.	None
RESISTOR R10	1. Open	1. No Loss of M507 Experiment. Increased 40KV.	None
	2. Short	2. No Loss of M507 Experiment. No Change	None
SWITCH S2A -03	1. Open	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Short (To Ground)	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
TRANSFORMER T4 -04	1. Short(Turn To Turn)	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Open(Either Winding)	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
SWITCH S2B -05	1. Open	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Short (To Ground)	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
CAPACITOR C42 -06	1. Short	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Open	2. No Loss of M507 Experiment. No Change	None
DIODE CR36 -07	1. Open	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Short	2. No Loss of M507 Experiment. 30% increase in 40KV.	None

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
CAPACITOR C41 -08	1. Short	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Open	2. No Loss of M507 Experiment. No Change	None
TRANSFORMER T2 -09	1. Short(Turn to Turn)	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Open(Either Winding)	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
CABLE 1.5KV -10	1. Short (To Ground)	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Open	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
CAPACITOR C4 -11	1. Short	1. No Loss of M507 Experiment. No Change	None
	2. Open	2. No Loss of M507 Experiment. No Change	None

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
CAPACITOR C13	1. Short	1. No Loss of M507 Experiment. Loss of 30% of 40KV	Decreased high voltage attraction.
-12	2. Open	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on. Low voltage adhesion and pilot light on.
DIODE CR8	1. Open	1. No Loss of M507 Experiment. Loss of 5% of 40KV.	None
-13	2. Short	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
CAPACITOR C14	1. Short	1. No Loss of M507 Experiment. Loss of 30% of 40KV.	Decreased high voltage attraction. Low voltage adhesion and pilot light on.
-14	2. Open	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	Decreased high voltage attraction. Low voltage adhesion and pilot light on.
DIODES CR9 through CR35	1. Open	1. No Loss of M507 Experiment. Loss of 3% of 40KV.	None
-15	2. Short	2. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
CAPACITOR C15 through C40 -16	1. Open	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Short	2. No Loss of M507 Experiment. Loss of 30% of 40KV.	Decreased high voltage attraction. Low voltage adhesion and pilot light on.
HIGH VOLT CABLE -17	1. Short (To Ground)	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.
	2. Open	1. No Loss of M507 Experiment. Loss of 40KV and loss of electrostatic field.	No high voltage attraction. Low voltage adhesion and pilot light on.

PART III

ELECTROSTATIC WORKBENCH ELECTRICAL SUBSYSTEM

POWER SUPPLY, LOW VOLTAGE

FMEA

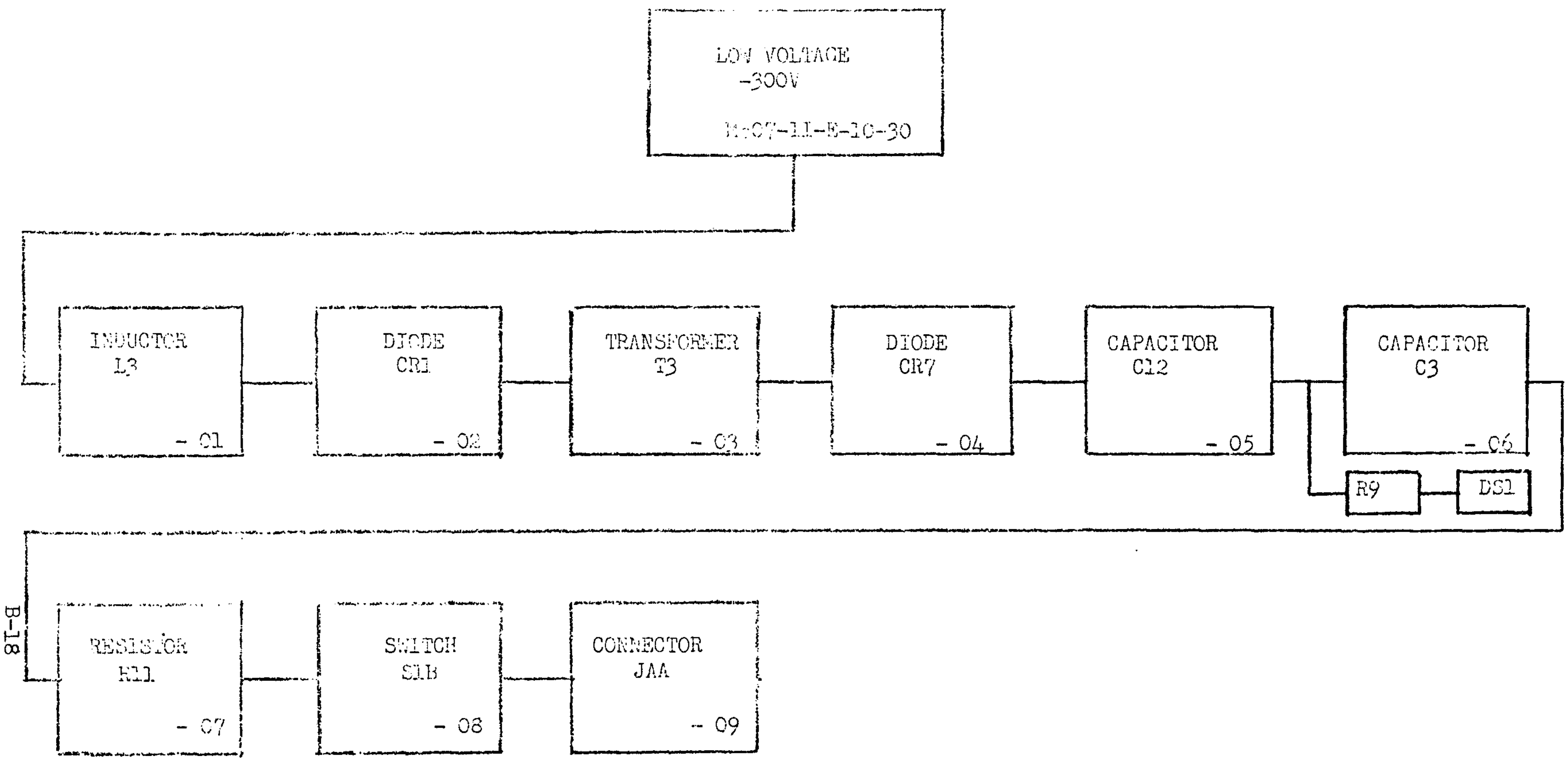


FIGURE 4. ELECTROSTATIC WORKBENCH POWER SUPPLY
LOW VOLTAGE RELIABILITY BLOCK DIAGRAM

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
ELECTROSTATIC POWER SUPPLY LOW VOLTAGE M507-II-E-10-20	1. Loss of output to table top.	1. No Loss of M507 Experiment. Loss of low voltage adhesive capability.	Sample object will not adhere to work table surface. High voltage attraction force is present. Sample object will loose high voltage charge when grounded. "Voltage on" (pilot light) on the electrostatic power supply will be off.
INDUCTOR L3	1. Short(Turn To Turn)	1. No Loss of M507 Experiment. No Change	None
-01	2. Open	2. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.
DIODE CR1	1. Open	1. No Loss of M507 Experiment. Loss of -300V	No adhesion. No pilot light indication.
-02	2. Short	2. No Loss of M507 Experiment. No Change	None
TRANSFORMER T3	1. Short(Turn To Turn)	1. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.
-03	2. Open(Either Winding)	2. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT		FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
DIODE	CR7 -04	1. Open	1. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.
		2. Short	2. No Loss of M507 Experiment. Loss of -300V. AC applied to table top.	No adhesion. Pilot light on.
CAPACITOR	C12 -05	1. Short	1. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.
		2. Open	2. No Loss of M507 Experiment. No Change	None
RESISTOR	R9	1. Open	1. No Loss of M507 Experiment. No Change	No pilot light indication.
		2. Short	2. No Loss of M507 Experiment. No Change	No pilot light indication.
LAMP	DS1	1. Short	1. No Loss of M507 Experiment. No Change	No pilot light indication.
CAPACITOR	C3 -06	1. Short	1. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.
		2. Open	2. No Loss of M507 Experiment. No Change	None

FAILURE MODES AND EFFECTS ANALYSIS

COMPONENT	FAILURE MODE	FAILURE EFFECT ON M507 EXPERIMENT	FAILURE DETECTION
RESISTOR R11	1. Open	1. No Loss of M507 Experiment. No Change	None
-07	2. Short	2. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.
SWITCH S1B	1. Open	1. No Loss of M507 Experiment. No Change (Safety Problem)	None
-08	2. Short (To Ground)	2. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.
CONNECTOR J1A	1. Open	1. No Loss of M507 Experiment. Loss of -300V.	No adhesion. Pilot light on.
-09	2. Short (To Ground)	2. No Loss of M507 Experiment. Loss of -300V.	No adhesion. No pilot light indication.

INTER COMPANY CORRESPONDENCE

TO - NAME	DEPT.	DIVISION	PLANT/OFFICE
P. E. Theobald	2730	Space	Michoud
FROM - NAME	**DEPT.**	**DIVISION**	**PLANT/OFFICE**
J. W. Christopher	2720	Space	Michoud

FILE CODE

DATE December 2, 1970

SUBJECT: ELECTROSTATIC WORK BENCH

Reliability Report

a. Failure History

The high voltage diode (10DF5) (CR8 through CR35) is the only component with a significant failure history. Enclosure 1 is a summary of the failure history.

b. Corrective Actions

Various corrective actions to improve the diode have been imposed on both the vendor and CCSD. These corrective actions included: the use of x-ray by both the supplier and CCSD, the use of a more flexible varnish, mold rework and vacuum potting by the supplier, the use at CCSD of prepotting with epoxy to about 10X volume.

J. W. Christopher
J. W. Christopher
Reliability & Logistics Engineering

JWC:ec

84-110-7879 REV. 1-63

HIGH VOLTAGE DIODE (10DF5) FAILURE DATA

Lot No.	Date	
1	5/4/70	PN-95M12037 (a) 28 diodes received out of vendor screened 100. (b) 4 failed, electrically open. (1) S/N 33 and 36 were sent to vendor for failure analysis. (2) S/N 12 and 15 were sectioned by CCSD. No knowledge to date on cause of failures. (c) 2 were electrically acceptable but were excluded for mechanical defects detected on x-ray film. (d) Squawk No. ESWB-0005.
2	5/19/70	PN-95M12037A (a) 36 diodes received out of vendor screened 50. (b) S/N 9, 10, 17, 26, 37 failed electrically open or shorted, they are at CCSD. (c) 36 examined by x-ray. (d) Squawk No. ESWB-0007.
3	6/15/70	PN-95M12037A (a) 18 diodes received out of vendor screened 19. (b) S/N 3, 8, 18, 19, 21, 22 failed, open or shorted, returned to vendor. (c) Squawk No. ESWB-0010.
4.	6/25/70	PN-95M12037A (a) 35 diodes received out of vendor screened 35.
	7/22/70	(b) S/N 22 open; S/N 15, 28 shorted. (c) Returned to vendor. (d) Squawk No. ESWB-0013.

Lot No.	Date		
5	7/15/70		PN-95M12037 (a) 73 received out of vendor screened 87. (b) S/N 3, 21, 25, 32, 35, 47, 73, 77 failed electrical tests.
	7/22/70		(c) S/N 4, 26, 56, 65, 37 also failed. (d) Returned to vendor. (e) Squawk No. ESWB-0017.

	6/3/70 Date Code	S/N	HIGH VOLTAGE MODULE PN-95M12022/95M12037
			(a) CR9, CR12, CR26, CR33 were found shorted after potting. S/N 1, 13, 34, 17.
CR9	018	1	
CR12	018	13	
CR26	018	34	(b) Potted unit scrapped.
CR33	020	17	
			(c) Squawk No. ESWB-0008.

SUMMARY

190 10DF5 diodes were received at CCSD. 35 or 18% of these failed.

616-61430
REV APR 66

INSPECTION SQUAWK SHEET

SHEET 1 OF ___

[X] SUPPLIED ITEM
[ ] R & D ITEM
[ ] GFE

SPACE DIVISION CHRYSLER CORPORATION

NO.	ASSEMBLY NO.	REV.
ESWB-000V	9V M12037	

STAGE NO	ASSY. NAME	SERIAL NO.
	Diode	12, 15, 33, 36

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
28		04		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
AJ.1	5/4/70	1	9V M12037	Forward voltage test on				CCSD IN-P 64 NASA A 27 MICH
1	R.H.	1	S/N 12, 15, 33, 36	the diodes S/N 12, 15, 33, 36				5-6-70
				indicate they are open.				
				NASA CONCURS WITH ABOVE SQUAWK				
				RECOMMEND PARTS BE RETURNED				
				TO VENDOR.				
				E. L. Nunes PM-MA QPA 5/4/70				
				Return parts to vendor.				
				P. Theobald 5/4/70				
				By agreement with Mr. Dee of Atlantic				
				Semiconductor, CCSD will section				
				S/N 12 & 15. S/N 33 & 36 are to be				
				returned to Atlantic immediately				
				P. Theobald 5/6/70				

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616-61?30
REV APR 65

INSPECTION SQUAWK SHEET

SHEET 1 OF 1

☒ SUPPLIED ITEM
☐ R & D ITEM
☐ GFE

SPACE DIVISION **CHRYSLER** CORPORATION

NO.	ASSEMBLY NO.		REV.
ESWB-0007	95M12037A		
STAGE NO	ASSY. NAME	SERIAL NO.	
	Diode	9,10,17,26,38	

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
		04		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
AS.1	5/19/70	1	95M12037A	During Forward Voltage drop	E17			CCSD IN-P 64 / NASA A 27 MICH
	R.D.	1	S/N 9,10,17,26,38	test; Diodes S/N 9, 10, 17, 26, 38	XX			11-13-70
				were found to be open.				
					NASA PM-MA-DDA			
					Concurs in the above			
					squawk and Recommends,			
					Return to vendor.			
					D L Leythem 5/19/70			
					Concur P. Therbold			11/13/70

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

SPACE DIVISION CHRYSLER CORPORATION

SHEET 1 OF 1

☑ SUPPLIED ITEM
☐ R & D ITEM
☐ GFE

NO.	ASSEMBLY NO.	REV.
ESWB-0008	95M12022	

STAGE NO	ASSY. NAME	SERIAL NO.
	High Voltage Module	Qualification unit #1

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		04		2V31

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
B-10	6/3/70 R.H.	1 / 1	95M12022	High Voltage Module (After inside Potting) has a diode -CR33- shorted in the reverse direction. Later testing found CR12, CR26, & CR9 shorted	E09 / 08			CCSD IN-P 64 8-11-70; NASA 27
				NASA PM-MA-QPA Concurs O.L. Leytham 6/3/70				
				This unit no longer useable; disposition: SCRAP Corrective action: prepotting of the high voltage diodes as shown in REV. A of 95M12022 — P. Theobald 8/11/70				
				NASA PM-MA-QPA, Recommends, use the above disposition. O.L. Leytham 8/11/70				

616-61-30
REV APR 66

INSPECTION SQUAWK SHEET

SHEET 1 OF 1

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

SPACE DIVISION CHRYSLER CORPORATION

NO.	ASSEMBLY NO.		REV.
ESWB-0010	95M12037A		
STAGE NO	ASSY. NAME	SERIAL NO.	
Lot #	Diode	3,8,18,19,21,22	

SHOP ORDER TOTAL QTY	~~SHOP ORDER~~ NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
18	A169483	04		2V-31

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION: DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL: DATE & INSPECTION STAMP
AV.1	6/15/70 RR	1 / 1	95M12037A S/N 3,8,18,19,21,22	During Forward Voltage drop test; Diodes S/N 3,8,18,19,21,22 were found to be open.	E17 / XX			IN-P 64 7-23

NASA PM-MA-QPA CONCURS IN THE ABOVE SQUAWK AND RECOMMENDS RETURN TO VENDOR.
[signature] PM-MA-QPA 15 June 70

CONCUR ON DISPOSITION
R. Theobald 22 July 70.

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

SHEET 1 OF 1

[X] SUPPLIED ITEM
[ ] R & D ITEM
[ ] GFE

SPACE DIVISION **CHRYSLER CORPORATION**

NO.	ASSEMBLY NO.	REV.
ESWA-0013	9V M12037A	
STAGE NO	ASSY. NAME	SERIAL NO.
	DIODE, Hi Voltage	22

SHOP ORDER TOTAL QTY	~~SHOP ORDER~~ Lot # NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
35	A169V03	04		2V31

OPER. ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
AV.1	6/25/70 R.N.	1 / 1	9VM12037A S/N 22	During Forward Voltage drop Test; Diode S/N 22 was found To be open.	E17 / XX			CCSD IN-P 64 7-23
					N.A.S.A PM-MA-QPA CONCURS IN THE ABOVE SQUAWK E.J. Peshek 6/26/70			
AV 2	7-22-70	1 / 1	9V M12037A S/N 1V + 28	DNE Shorted junction each Diode				CCSD IN-P 64 7-23-70
				NASA PM-MA-QPA CONCURS IN THE ABOVE SQUAWK E J Peshek 7/22/70				
					DISPOSITION: RETURN TO VENDOR - [illegible] 22 July 70			
					NASA PM-MA-QPA CONCURS IN DISPOSITION [illegible] 7/23/70			

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REV APR 66

INSPECTION SQUAWK SHEET

SPACE DIVISION CHRYSLER CORPORATION

SHEET 1 OF ___

☑ SUPPLIED ITEM
☐ R & D ITEM
☐ GFE

NO.	ASSEMBLY NO.	REV.
ESWB-0017	95M12037	
STAGE NO: IMR	ASSY. NAME: H.V. Diodes	SERIAL NO. 47,73,77 3,21,32,25,35,

SHOP ORDER TOTAL QTY	~~SHOP ORDER~~ NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
73	A169527	04		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION: DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL: DATE & INSPECTION STAMP
A5	7-17-70	73	95M12037	During Forward Voltage	E17			CCSD IN-P 64 NASA 27 MICH
1	R.F.	8	S/N 3,21,25,32,35,	drop Test. Diodes S/N 3,21,	XX			7-23-70
			47,73,77	25,32,35,47,73,77 were				
				found To be open.				
				NASA PM-MA-QPA Concurs				
				IN The above squawk				
				[illegible] 7/17/70				
A5	7-22-70	73	95M12037	S/N 4-exposed varnish				CCSD IN-P 64 NASA 27 MICH
2	R.F.	5	S/N 4,26,56,65,37	S/N 65-foreign metalic material				7-23-70
				within potting.				
				S/N 26,37,56 - one shorted junction				
				each.				
				NASA PM-MA-QPA concurs in the				
				above squawk [illegible] 7-22-70				
					DISPOSITION: RETURN TO VENDOR.			
					[illegible] 7/22/70			
					NASA PMMA QPA Concurs			
					in Disposition			
					[illegible] 7/23/70			

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APPENDIX C

QUALIFICATION TEST REPORT

ABSTRACT

This document presents the test procedures and results of tests performed on the Electrostatic Gravity Substitute Workbench to establish its qualification for use in the Skylab Experiment M507.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

FOREWORD

The tests reported herein were conducted for the Marshall Space Flight Center by Chrysler Corporation Space Division (CCSD), New Orleans, Louisiana. This document was prepared by CCSD under contract NAS8-21385. Technical direction was provided by Mr. J. B. Rendall, S&E-ME-MX of the Marshall Space Flight Center in his capacity as Principal Investigator for Skylab Experiment M-507.

QUALIFICATION TEST REPORT
FOR AN
ELECTROSTATIC GRAVITY SUBSTITUTE WORKBENCH
NASA DRAWING NO. 95M12015

1.0 OBJECT

The object of the test program was to establish qualification of the Electrostatic Gravity Substitute Workbench (EGSW) for use in the Skylab Experiment M-507.

2.0 CONCLUSIONS

The EGSW is considered to have passed the environmental tests. Two facts were conclusively demonstrated: 1) There were no serious structural weaknesses in the design, and 2) The electronic assembly successfully withstood all test environments.

The following anomalies were encountered:

a. During the vibration test a spring pin on the adjustable storage bracket was found to have been sheared. This was attributed to the application of excessive torque while tightening the thumb screw. It was replaced and testing continued without recurrence of this problem. Thereafter technicians were careful not to exceed the torque specified.

b. A weakened bond between the ion shield and connecting block was observed after the first vibration test. No corrective action was taken and the condition did not worsen during the remainder of the tests. There was no structural or functional failure.

c. A weakened joint between the fiberglass support rod and the ion shield block was observed about midway through the testing. No corrective action was taken and the condition did not worsen during the remainder of the tests. There was no structural or functional failure.

d. At the start of the altitude test, electroadhesive force measurements showed little or no pull on the test disc. This problem was not caused by the environmental test exposures. The force test fixture and method of attaching to the test disc are major factors affecting ion flow to the disc.

3.0 RECOMMENDATIONS

Although the EGSW is considered to have passed the environmental tests, further effort should be expended to resolve the problems encountered during the various electroadhesive force measurement tests.

4.0 DISCUSSION

4.1 Test Article Description

Figure 1 illustrates the EGSW unit which was used in all qualification testing. The unit was built specifically for this purpose, and is called the Qualification Unit. It was fabricated to the documentation defined by drawing 95M12015, Electrostatic Workbench Assembly, and employed the same procedures as used for the flight and backup units.

4.2 Tests

Qualification testing was performed in accordance with the Qualification Test Specifications and Procedures for an Electrostatic Gravity Substitute Workbench (appendix B).

To clarify the sequence of all testing, both functional and environmental and points of inspection, Quality Control Instructions (QCI's) were prepared and are included as appendix C.

4.2.1 Functional

Functional tests were conducted,at ambient conditions, prior to environmental exposure and after each environmental exposure. Functional tests consisted of an electrostatic voltage test and electroadhesive force measurements. These are described in paragraphs 3.3.1 and 3.3.2 of appendix I to the Qualification Test Specifications and Procedures. A photograph of the force test fixture is shown in figure 2, and a schematic of the suspension geometry is illustrated in figure 3.

4.2.2 Electromagnetic Interference

The electromagnetic interference tests, because of the manner in which they are usually conducted and reported, are detailed and the results recorded in appendix A.

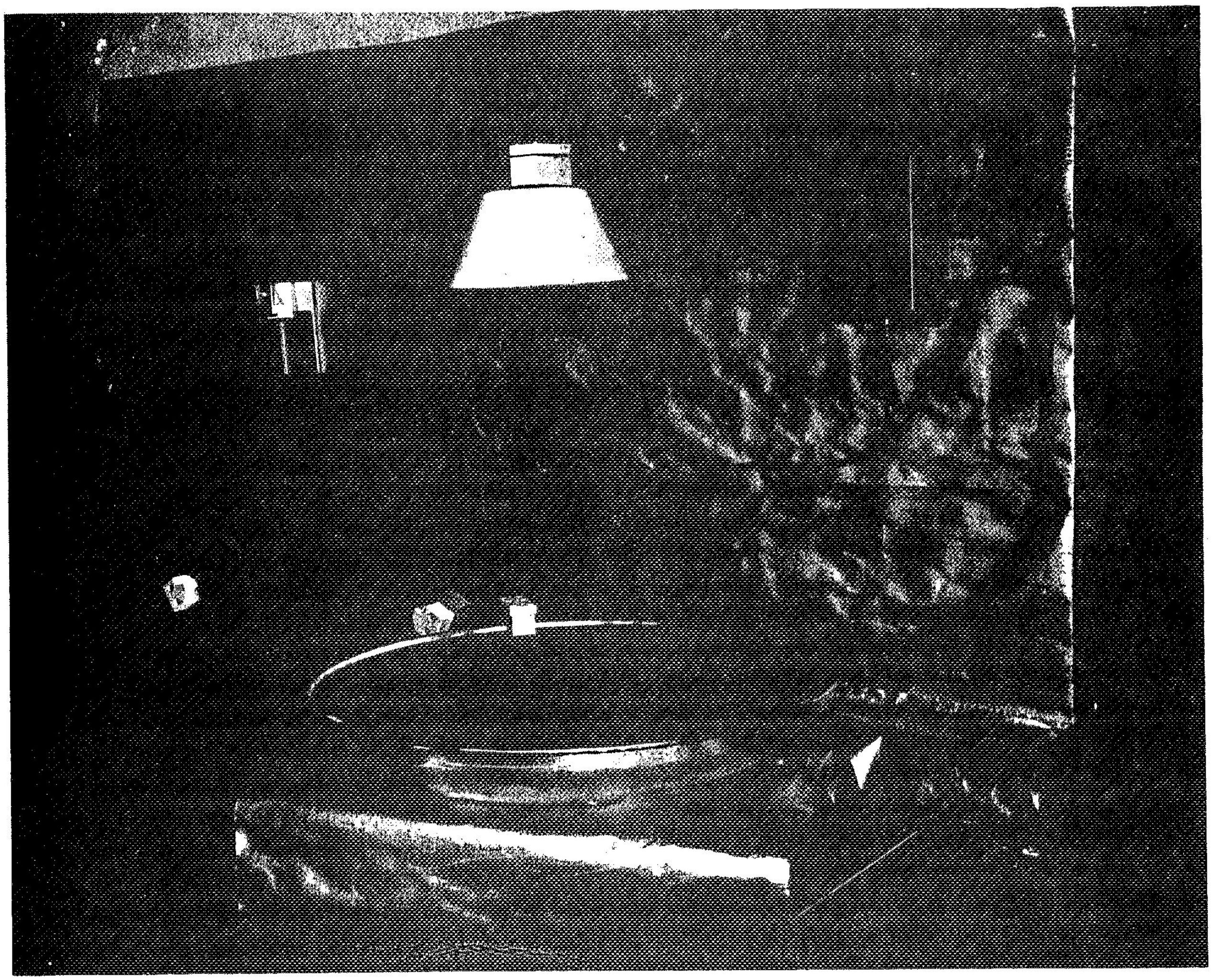


Figure 1. Electrostatic Gravity Substitute Workbench

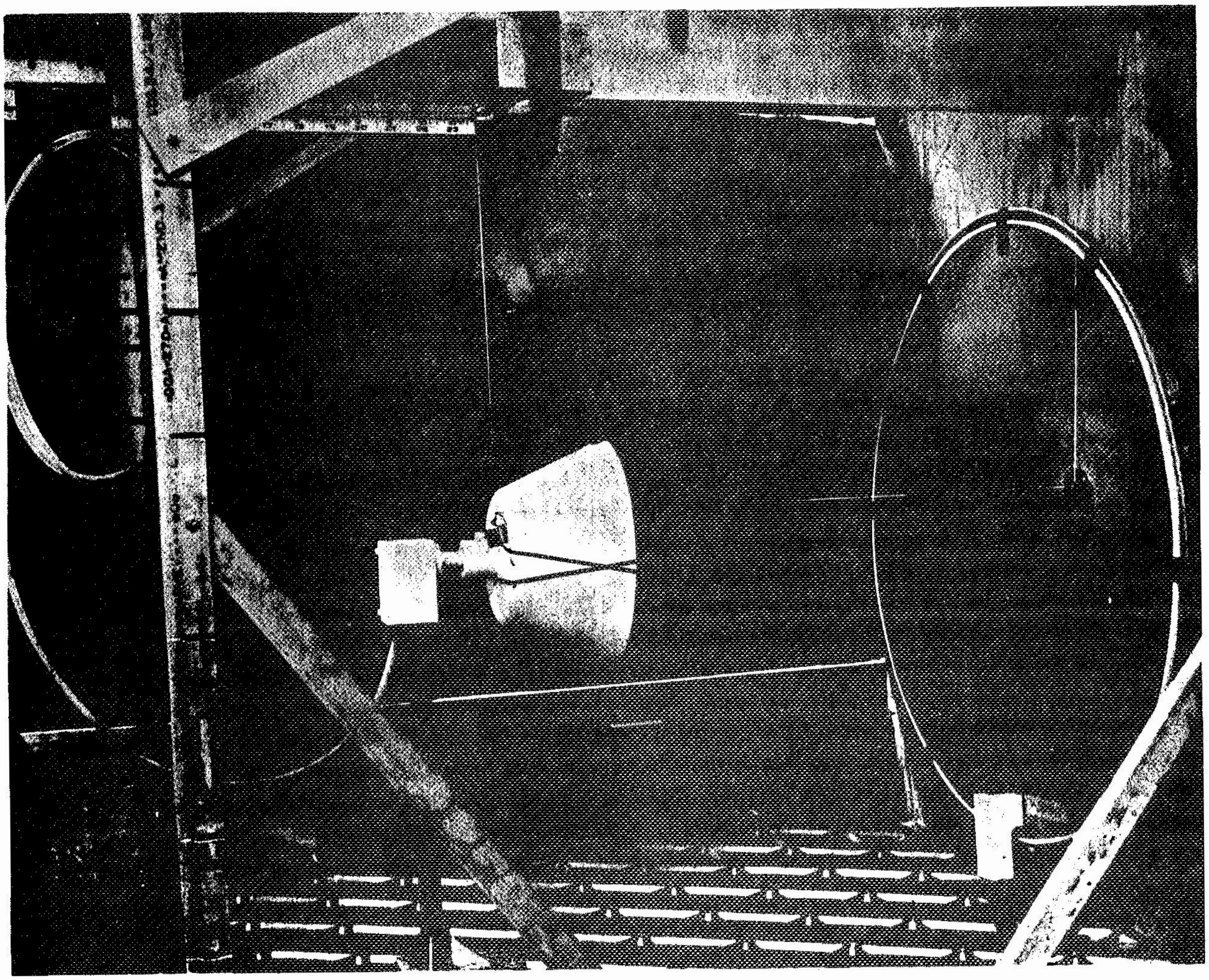
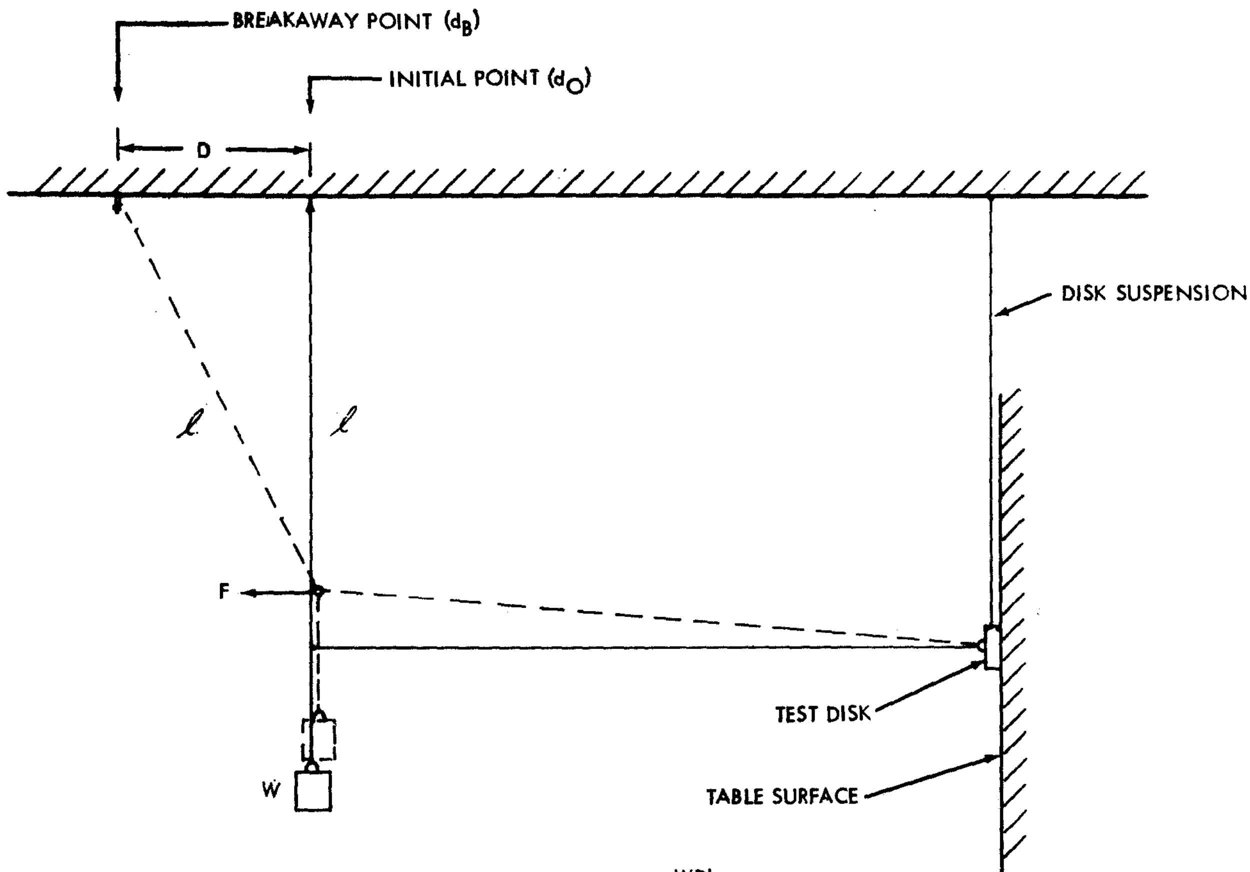


Figure 2. Force Test Fixture



APPROXIMATE FORMULA: $F = \dfrac{WDh}{\sqrt{\ell^2 - D^2}\,(D+h) - D\ell}$ $\quad D = d_B - d_O$

Figure 3. Force Test Fixture - Schematic

4.2.3 Low Temperature

The EGSW was placed in the low temperature chamber and functional tests were successfully performed at ambient conditions. (See data sheets 4-1, 4-2, and 4-3, appendix D.)

The chamber was then closed and the temperature lowered at a rate of 10°F each five minutes until the chamber temperature reached -50°F, where it was allowed to stabilize for approximately 95 hours. The temperature was raised to ambient conditions at the rate of 10°F each five minutes and allowed to stabilize for approximately four hours before the chamber was opened. (See temperature recorder chart 5-1, appendix D.)

The post-low temperature and pre-high temperature functional tests were performed and results are shown on data sheets 6-1, 6-2, and 6-3 of appendix D.

The electroadhesive force measurement was satisfactory but the electrostatic field voltage did not meet the specified requirement. In switch position 1 the reading was 1.5KV, and in switch position 2 the reading was 6.4KV, whereas the minimum requirement was 3KV and 8KV, respectively. Since the corresponding electroadhesive forces were good, it was felt that the system was functioning satisfactorily and that the minimum electrostatic field voltage requirement should be lowered. This was accomplished by changing the requirement to a minimum of 1.3KV and 6.0KV for switch positions 1 and 2, respectively. (See Inspection Squawk Sheet No. ESWB-0037, appendix E.)

4.2.4 High Temperature

The EGSW was then moved to the high temperature chamber. The temperature was raised at the rate of 10°F each five minutes until the chamber temperature reached 160°F where is was allowed to stabilize for 48 hours. Chamber temperature was then lowered to ambient at the rate of 10°F each five minutes. Throughout the high temperature exposure period, relative humidity was maintained below 15 percent. For a record of the dry-bulb and wet-bulb temperatures, see the recorder charts 7-1 and 7-2, appendix D.

The following morning the EGSW was moved back to the low temperature chamber where the functional test had been performed; the functional test was then successfully repeated. (See data sheets 8-1, 8-2, and 8-3, appendix D.)

4.2.5 Altitude

At this stage, modifications had to be made and checked out before running functional tests remotely with the equipment inside the altitude chamber at reduced pressure. This involved operating and resetting the pull mechanism, permanently fastening an electrostatic voltage pick-off at the ion shield cover, installing thermocouples for chamber temperature and for power supply case temperature, providing for remotely operating selector switch S2, and of course running electrical and hydraulic power and control leads through the bulkhead. The remotely controlled selector switch,employing a hydraulic servo system, was the most elaborate setup used.

During the installation and checkout of the remote control system it was noted that the suspension strings in the force fixture were becoming worn. These cotton threads, which had little strength, were replaced by fiberglass multifilament thread.

In checking out the system prior to the formal pre-altitude functional test it was found that, though the electrostatic voltage readings were satisfactory, the electroadhesive pulls were extremely poor. After several days of diagnostic testing, it was discovered that dampness on the threads appeared to be a factor in achieving successful pulls. Due to the limited testing time available, it was decided to proceed with testing without regard to out-of-tolerance electroadhesive pull measurements.

The pre-altitude test was performed. The electrostatic voltage test passed; the electroadhesive force measurements failed. (See data sheets 11-1, 11-2, and 11-3, appendix D.) The test discrepancy is documented in Squawk Sheet No. ESWB-0040, appendix E.

Chamber pressure was gradually lowered to the maximum capability of the chamber. The pressure was maintained for 8 hours between 1.6×10^{-2} and 1.4×10^{-2} mm of mercury. This minimum pressure did not meet the specification and is documented by Squawk Sheet No. ESWB-0045, appendix E.

The pressure was then raised to 258 mm of mercury where it was allowed to stabilize. The power was turned on and the temperature of the power supply case was monitored. The case temperature reached a maximum of 112°F (a temperature rise of 20°F over the chamber ambient).

After one hour of operation with the power on, a functional test was performed. This was the same as previous functional tests except that the table could not be reoriented, and currents could not be read. The electrostatic voltage test was satisfactory; the electroadhesive force measurements failed. (See data sheets 15-1 and 15-2, appendix D.) The failure is documented by Squawk Sheet No. ESWB-0041, appendix E.

After completion of the functional testing at 258 mm of mercury, the pressure was raised to ambient, and another functional test performed. The electrostatic voltage test passed; the electroadhesive force measurements failed. (See data sheets 16-1, 16-2, and 16-3, appendix D.) The failure is documented by Squawk Sheet No. 0042, appendix E. This completed the altitude testing. A plot of the pressure/altitude history during the test is shown in figure 4.

4.2.6 Vibration

Vibration testing was divided into four vibration modes as follows:

a. Vehicle Dynamics (Sinusoidal Sweep)
b. Sinusoidal Evaluation (Sweep)
c. Liftoff Random
d. Boost Random

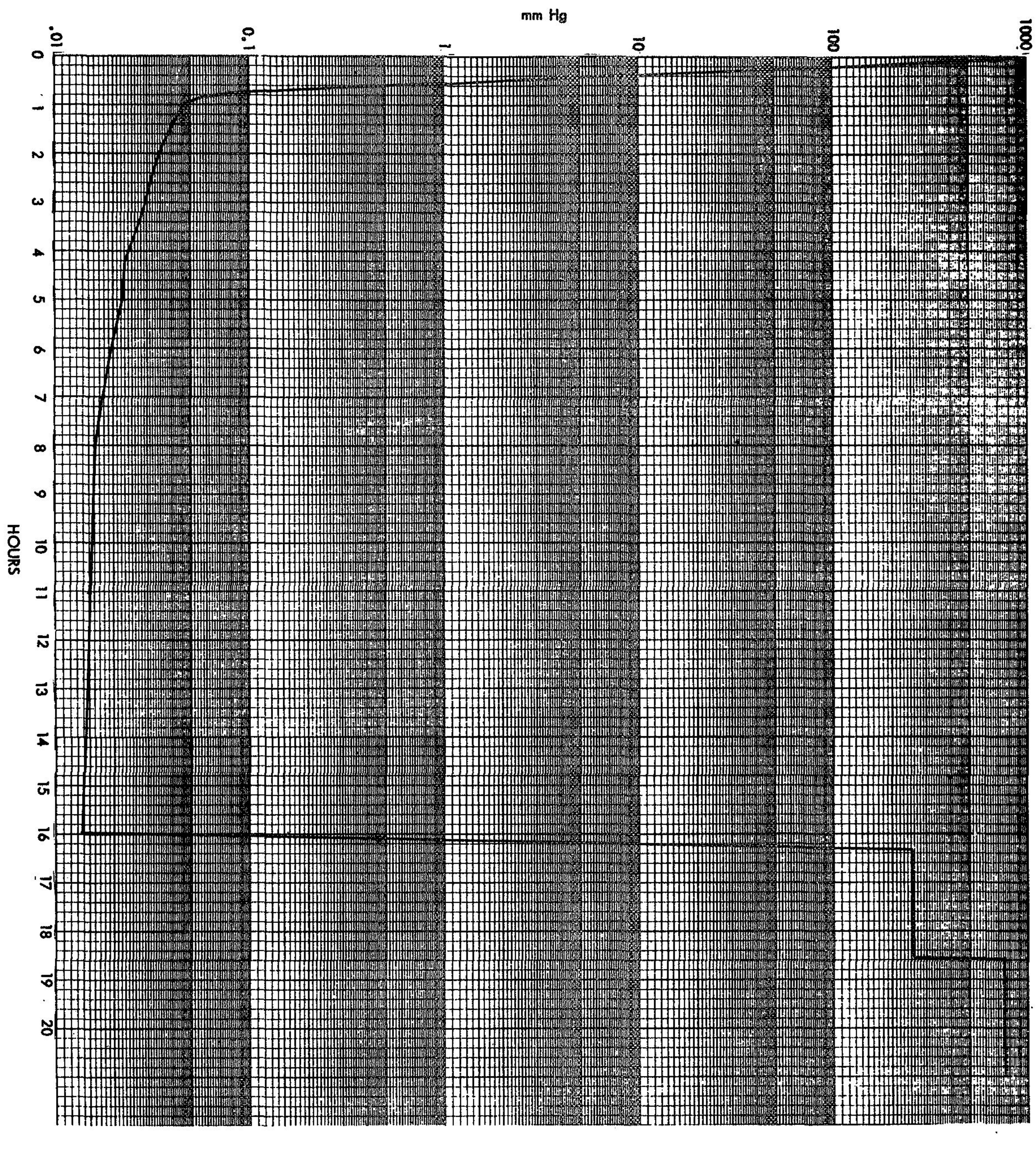


Figure 4. Pressure vs. Time - Plot

Vibration was applied in each of the three perpendicular axes in each mode. Figure 5, which shows the EGSW mounted in the workshop in the stored configuration, defines the three vibration axes. Since the fixture is not capable of handling the table top, the ion shield and power supply at the same time, two setups were required for each axis of each vibration mode.

Figure 6 shows the power supply and ion shield mounted in the flight axis. Note that the table top is not being vibrated, although the connector to the power supply is attached. The next step was to remove the power supply and ion shield and install the table top mounted in its Skylab storage brackets. Altogether, 24 vibration runs were required to complete the vibration requirement.

Because of the extremely low vibration levels involved, levels at which the electromagnetic shaker cannot be controlled, there were certain portions of the vibration test requirements that were beyond the capability of the laboratory vibration equipment. These test levels were omitted and are documented by squawk sheets, appendix E. The omitted portions, with the applicable squawk sheet referenced, are as follows:

a. Vehicle Dynamics Criteria

Flight Axis

3-5Hz at 0.43-inch D.A.
Ref: Squawk Sheet No. ESWB-0046, sheet 1

b. Vehicle Dynamics Criteria

Both lateral axes

Complete Specification
Ref: Squawk Sheet No. ESWB-0046, sheet 3

c. Sinusoidal Evaluation Criteria

All Axes

20-100 Hz at 0.002 inches D.A.
Ref: Squawk Sheet No. ESWB-0046, sheet 5

The vibration levels performed are as follows:

a. Vehicle Dynamics - Sweep Rate: 3 octaves/minute

Flight Axis Only

5 to 7 Hz at 0.43 inches D.A.
7 to 14 Hz at 1.1 g peak
14 to 25 Hz at 0.11 inches D.A.
25 to 60 Hz at 3.6 g peak

b. Sinusoidal Evaluation - Sweep Rate: 1 octave/minute

All Axes

100 to 2000 Hz at 1.0 g peak

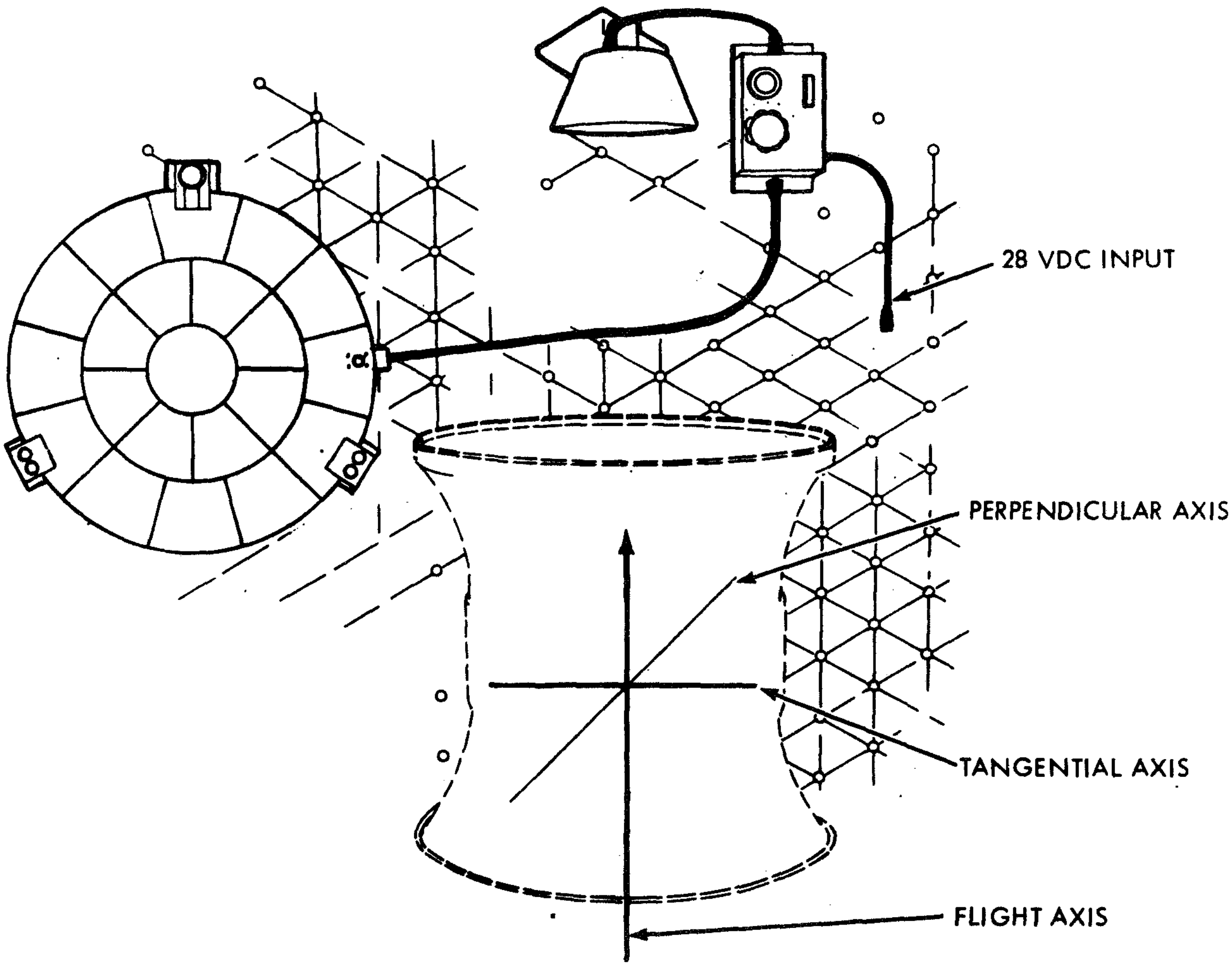


Figure 5. EGSW - Stored Configuration

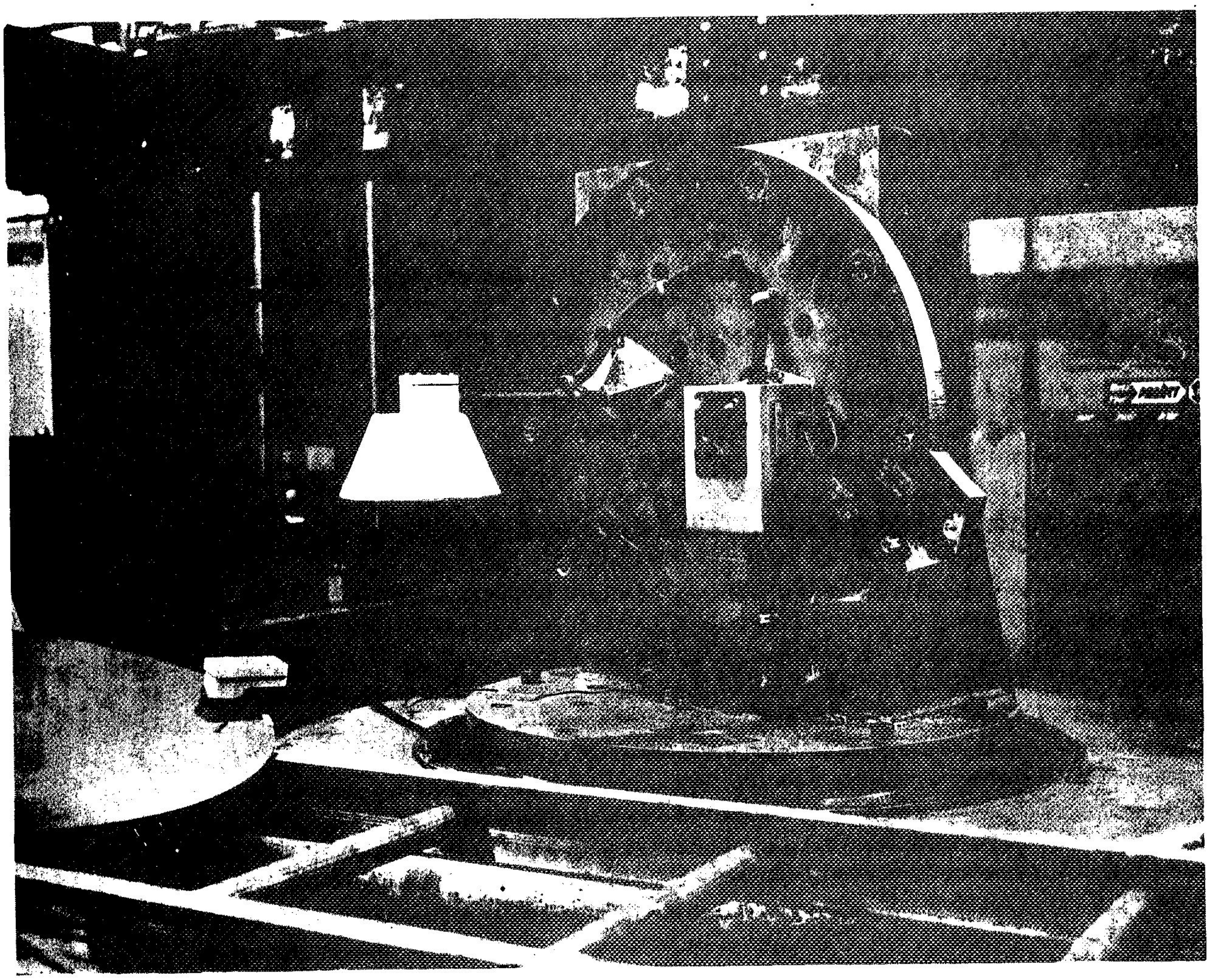


Figure 6. EGSW - Mounted on Shaker

c. Liftoff Random - Duration: One minute per axis

Flight Axis

20 to 30 Hz at 0.10 g^2/Hz
30 to 1000 Hz at -3 db/octave
1000 to 2000 Hz at 0.003 g^2/Hz
Composite = 4.1 g_{rms}

Tangential to wall

20 to 100 Hz at 0.10 g^2/Hz
100 to 2000 Hz at -3 db/octave
2000 Hz at 0.005 g^2/Hz
Composite = 6.2 g_{rms}

Perpendicular to wall

20 to 100 Hz at -3 db/octave
100 to 2000 Hz at 0.006 g^2/Hz
Composite = 3.5 g_{rms}

d. Boost Random - Duration: 2 minutes per axis

Flight Axis

20 to 30 Hz at 0.025 g^2/Hz
30 to 1000 Hz at -3 db/octave
1000 to 2000 Hz at 0.0007 g^2/Hz
Composite = 1.9 g_{rms}

Tangential to wall

20 to 100 Hz at 0.025 g^2/Hz
100 to 2000 Hz at -3 db/octave
2000 Hz at 0.0012 g^2/Hz
Composite = 3.1 g_{rms}

Perpendicular to wall

20 to 2000 Hz at 0.0075 g^2/Hz
Composite = 3.9 g_{rms}

An electrostatic voltage test was performed prior to any vibration test and after each axis of each vibration mode; i.e., after each pair of vibration runs consisting of the power supply and ion shield, and table top. After the final vibration run the electroadhesive force measurements were performed in addition to an electrostatic voltage test. The electrostatic voltage tests were all successful. (See data sheets 18, 23, 33, 38, 43, 48, 53, 58, 63, 68, 73, and 78-1, appendix D.) The final electroadhesive force measurements were again a failure. (See data sheet 78-2 and 78-3, appendix D.) Squawk Sheet No. ESWB-0052, appendix E, documents the failure of the force measurement test. Of course this failure in the force measurement test cannot be attributed to vibration, since the same symptoms were evident prior to vibration testing.

There were three items noticed by visual inspection at various times during the vibration sequence.

1) After the vehicle dynamics sweep in the flight axis, it was noted that the bond between the ion shield and the teflon block had weakened. This area was carefully watched during subsequent vibrations and no propagation of the damage was found. There was apparently enough strength in the remainder of the bond as well as in the three screws holding the parts together to retain structural integrity. (See Squawk Sheet No. ESWB-0046, sheet 2, appendix E.)

2) When the table top was being mounted for the sinusoidal evaluation test in the tangential axis it was found that the spring pin which secures the knob to the threaded shaft in the adjustable storage bracket had sheared off. No evidence of failure due to vibration was discovered. It is felt that it occurred from excessive torque in tightening the clamp onto the table top and a limiting torque value has been added to the applicable drawing. (See Squawk Sheet No. ESWB-0046, sheet 4, appendix E.)

3) Finally, after the liftoff random test in the tangential axis, the joint between the fiberglass support rod and the ion shield block appeared to have a small amount of torsional looseness. These two parts are held together by means of a press fit and a teflon dowel pin. This weakening was assessed as being minor, and sufficient structural integrity remained. Squawk Sheet No. ESWB-0046, sheet 6, appendix E reports this deviation.

Table 1 summarizes the vibration sequence. Appendix F includes recorded vibration plots for the sinusoidal sweep tests as well as the power spectral density plots for the random vibration tests. See appendix G for a copy of the Qualification Test Log.

4.2.7 Force Test Fixture Anomaly

As noted in paragraph 4.2.5, during the altitude test sequence the test disk suspension threads were replaced and it was immediately noted that very little or no force could be measured. There are two methods of creating electro-adhesive force between the test disk and the table surface: a direct application of a 300 vdc bias between disk and table, and by establishing a charge on the disk by supplying it with (+) ions from the emitter. The latter method is the one desired and requires that the disk suspension thread and horizontal pull thread be non-conductive. These threads become partially conductive when contaminated with foreign materials and/or moisture and the system begins to function as in the bias method. This is evidently what had happened and when fresh, dry thread was substituted, insufficient ions were being supplied to the test disk to create the desired force.

Table 1. Vibration Sequence Chart

	Vibration Mode				Axis			Configuration		
Test Number	Vehicle Dynamics	Sinusoidal Evaluation	Liftoff Random	Boost Random	Flight	Tangential	Perpendicular	Power Supply & Ion Shield	Table Top	Remarks
1	x				x			x		Weakened Bond (App E, ESWG-0046, Sh. 2)
2	x				x				x	
3	x					x		x		
4	x					x			x	Test Omitted
5	x						x	x		
6	x						x		x	
7		x					x	x		
8		x					x		x	
9		x				x		x		
10		x				x			x	Sheared off pin (App E, ESWB-0046, Sh. 4)
11		x			x			x		
12		x			x				x	
13			x		x			x		
14			x		x				x	
15			x			x		x		Weakened Joint (App E, ESWB-0046, Sh. 6)
16			x			x			x	
17			x				x	x		
18			x				x		x	
19				x			x	x		
20				x			x		x	
21				x		x		x		
22				x		x			x	
23				x	x			x		
24				x	x				x	

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APPENDIX A

ELECTROMAGNETIC INTERFERENCE TEST REPORT

FOR THE

ELECTROSTATIC GRAVITY SUBSTITUTE WORKBENCH

ELECTROMAGNETIC INTERFERENCE TEST REPORT

FOR THE

GRAVITY SUBSTITUTE WORKBENCH (ELECTROSTATIC)

1. GENERAL

1.1 Purpose of Test

The test was performed to determine the levels of electromagnetic interference (EMI) generated by the Gravity Substitute Workbench as required by MIL-I-6181-D and as outlined in the "Qualification Test, Specifications and Procedures" for the Gravity Substitute Workbench (Electrostatic) E.M.I. Test Plan, Appendix II.

1.2 Test Sample

The test sample was an Electrostatic Workbench Assembly, (Part No. 95M12015) Serial Number "Qual Unit" and as later modified by replacing the ion shield bleed cover and substituting the prototype tabletop.

1.3 Date of Test

The test was performed on August 27th and 28th, and September 14th and 15th, 1970.

1.4 Test Conductor

The test was conducted by E. Lukawski, Chrysler Corporation Space Division (CCSD) Instrumentation Section.

1.5 Test Witnesses

The test was witnessed by Robert Faucheux and C. K. Johnson, CCSD Quality Control and O. L. Leytham, National Aeronautics and Space Administration (NASA) Quality Control Department.

1.6 Test Location

The test was conducted in the shielded enclosure located in the Electromagnetic Interference Laboratory at Michoud Assembly Facility.

The enclosure is a double electromagnetic-shielded enclosure certified by the Shielding Division of Shieldtron, Inc., in November 1963.

1.7 Disposition of Specimen

The test specimen was used for the remaining qualification tests.

1.8 Summary

1.8.1 Conducted Interference Measurements

The level of conducted interference detected on both input leads was far below the specification limits.

1.8.2 Radiated Interference Measurements

The level of radiated interference measured from 0.15 mhz to 1.0 mhz exceeded the specification limit by approximately an average of 20 db. A peak was detected at 11.7 mhz which exceeds the spec. limit by about 12 db.

The radiated measurements at the 15 mhz to 400 mhz region was within the specification limits.

2. TEST DATA

Appendix B shows all measured and plotted data.

2.1 Description of Test Equipment

Item No.	Description	Manufacturer	Model	I.D. #
1	Noise and Field Intensity Meter, including vertical and Dipole Antennas	Empire Devices	N.F. 105	2314
2	LISN	Filtron	FRS 701D	014413
3	LISN	"	FRS 701D	014419
4	50 ohm termination	Hewlett Packard	908A	010338
5	" " "	" "	908A	010340
6	Milliohmeter	Shallcross	670A	016959

2.2 Sample Calculations

2.2.1 Interference measuring equipment, NF 105 (41 inch rod antenna)

Calculation of the interference level of the broadband radiated measurement at 2.0 mhz is as follows:

Antenna factor (VA-105)	10 db
Meter Correction Factor (MCF substitution method)	20 db
Measured level	47 db/μv/mhz

Interference level = measured level + MCF & Antenna Factor
= 47 + 20 + 10 = 77 db/μv/mhz

2.2.2 Interference Measuring Equipment, NF 105 (DM 105 T1 and T2 Antennas)

Calculation of the interference level of the broadband radiated measurement using dipole DM 105 T1 antenna at 100 mhz is as follows:

Measured level at 100 mhz	32.0 db
Cable loss of 30 ft. RG 55/U at 100 mhz	1.3 db
Mismatch of 72 ohm antenna to 50 ohm cable	1.7 db
Open circuit factor (antenna induced)	6.0 db

Interference level = 32 db/μv/mhz + 1.3 + 1.7 + 6.0
= 41 db/μv/mhz

3. TEST CONDITIONS AND PROCEDURES

3.1 Test Condition

3.1.1 Input Power Source

The electrostatic power supply was operated from a voltage source at a nominal voltage of 28 vdc with an output impedance of less than one (1) ohm.

3.1.2 Method of test sample operation

The test sample was operated in 2 modes during the EMI tests. Switch position 2 and switch position 4 provided an output voltage of approximately 20 KV and 40 KV, respectively, to the ion emitter.

3.1.3 Bonding

A d.c. resistance of 300 micro-ohms was measured between the electrostatic power module base plate and the EMI ground plane with a Shallcross milliohmeter, model 670A. Because a satisfactory bond was obtained by metal to metal contact using "C" clamps, no additional bonding was required.

3.2 Test Procedures

3.2.1 Conducted Interference Measurements using Line Impedance Stabilization Networks (LISN)

Appendix A, figure 1, shows the typical test configuration. Conducted interference measurements were performed by connecting the signal input of the NF 105 to the LISN in the positive 28 vdc input power lead while terminating the LISN in the negative 28 volt d.c. circuit with a 50 ohm load. Signal levels were recorded while the power module was set at the 20 KV and the 40 KV output switch position.

The tests were repeated as in above except that measurements were made by monitoring the minus 28 volt input power lead. The LISN positive signal circuit was terminated in a 50 ohm load.

3.2.2 Radiated Interference Measurements

Appendix A, figure 2, 3, and 4 show the typical test configuration. Radiated measurements were performed by connecting the NF 105 signal input to a tuned antenna (41 inch rod antenna from 0.15 to 30 mhz and tuned dipoles from 30 to 400 mhz) and positioning the antenna as specified in MIL-I-6181D. Signal levels were measured in the test frequency spectrum between 0.15 and 400 mhz at both the 20 KV and 40 KV output switch settings on the electrostatic power module.

Complete radiated interference measurements were repeated as above after the bleed cover was replaced and the prototype tabletop was installed.

3.2.3 General

3.2.3.1 Interference Measuring Equipment Adjustment

Broadband interference was measured with the NF 105 substitution technique using the internal impulse generator. With the NF 105 in peak detector function, a reference level of the unknown interference was set by the signal input attenuator and I.F. gain control. The impulse generator was then adjusted to match that reference level. The interference level was read as the impulse generator output level required to match the reference level.

3.2.3.2 Frequency Selection

The NF 105 was slowly tuned through the frequency range of each test. The frequencies at which maximum interference was obtained were chosen as test frequencies.

4. TEST RESULTS

4.1 Conducted Interference Measurements

Conducted Interference Measurements using Line Impedance Stabilization Networks (LISN)

The measured data can be found in appendix B, pages 1 and 2; the plotted data in Appendix B, figure 5. Measured interference levels were well within the MIL-I-6181D specified limits. The highest levels measured in both the negative and positive 28 volt leads was 59 db/μv/mhz broadband interference.

4.2 Radiated Interference Measurements

Broadband interference was detected during radiated interference measurements performed before and after table and bleed cover modifications. The measured data can be found in Appendix B, pages 3, 4, 5, and 6. The plotted data for these measurements can be found in Appendix B, figures 6 and 7. The broadband interference levels measured from 15 mhz to 400 mhz were acceptable in accordance with the MIL-I-6181D requirements in both the 20 KV and 40 KV output settings of the power module. Generally, the broadband interference limits of MIL-I-6181D were exceeded in the 0.15 to 14 mhz range with the 20 KV output falling within specifications from 1.4 to 4.0 mhz and 5 through 10 mhz range in the "pre-modified bleed cover" mode. In the second radiated interference test performed, using the modified bleed cover and prototype table, interference levels increased in both the 20 KV and 40 KV output settings from 0.15 to 4.0 mhz only. Improvement was noted from 14 to 400 mhz. In all cases, the radiated interference levels dropped significantly at the 20 KV output setting of the power module. This condition was the result of lower breakdown or corona producing levels. The high peaks at approximately 4.5 mhz and 11.7 mhz were accompanied by a low frequency tone modulating these RF frequencies. Due to the natural square wave characteristics of a transistor switching power supply, harmonics were generated and seemed to resonate at the 4.5 and 11.7 mhz frequencies. Due to the narrow band characteristics of these peaks, the levels fall within the narrow band requirements of MIL-I-6181D.

4.3 Conclusions and Recommendations

The performance characteristics of the gravity substitute workbench in regard to providing a minimum amount of radiated interference was considered good. Considering the high voltages and corona characteristics involved, the high frequency spectrum noise was favorably low.

Low frequency spectrum radiated noise levels were excessive from 0.15 mhz to 4 mhz and at one point near 11.7 mhz. This may be improved in future units by incorporating additional filtering in the minus (-) 300 volt output lead within the power module.

Conducted interference suppression characteristics in the negative and positive 28 volt power lines were found to be very good.

Since the radiated interference level is a function of the D.C. high voltage output of the power module, the lowest output settings consistent with gravity substitution requirements should be used.

APPENDIX A

TO THE

ELECTROMAGNETIC INTERFERENCE TEST REPORT

(CONFIGURATION DIAGRAMS)

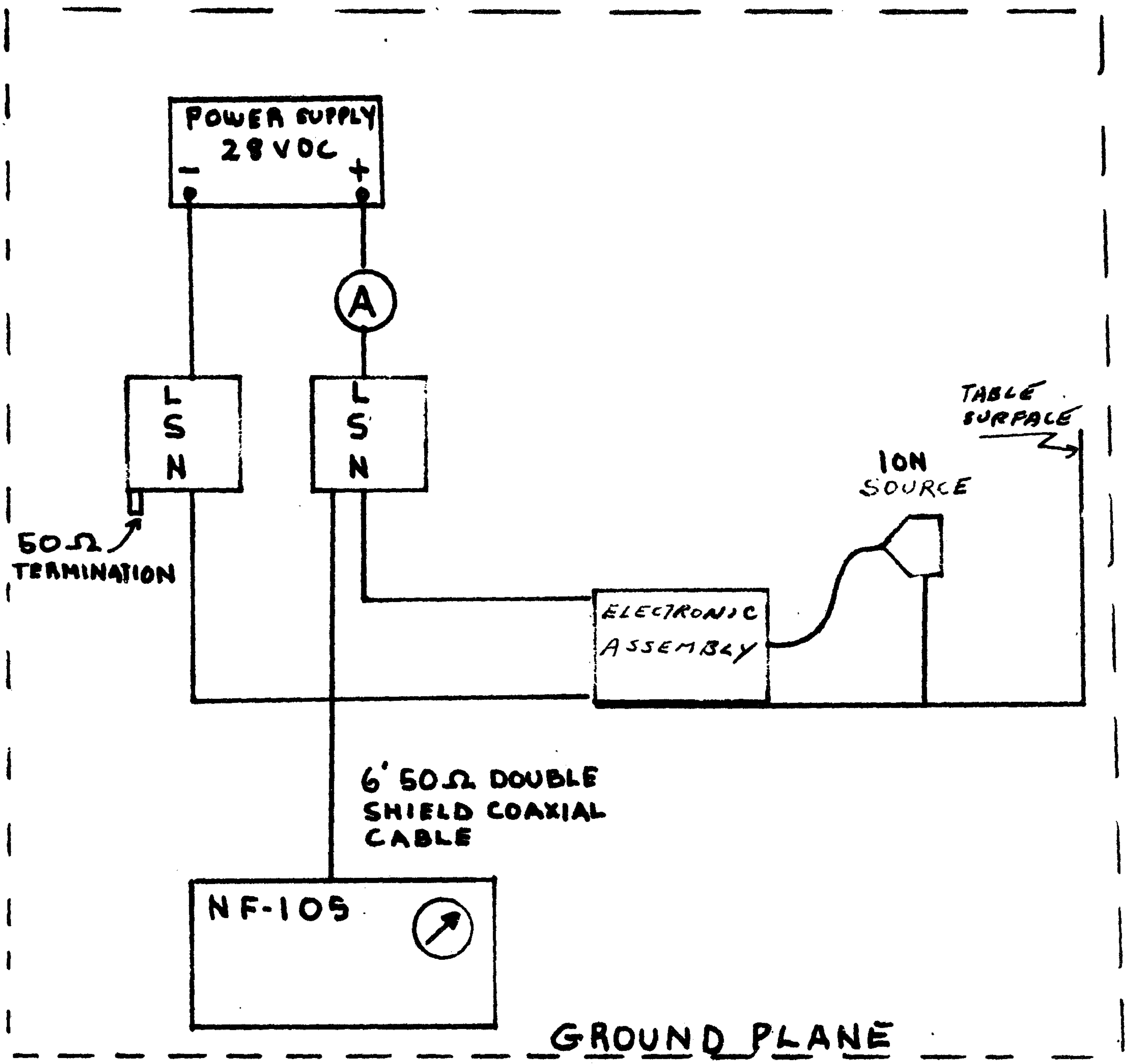


Figure 1. Conducted Interference (LSN) Measurements Test Configuration (Frequency Spectrum 0.15 to 25 MHz)

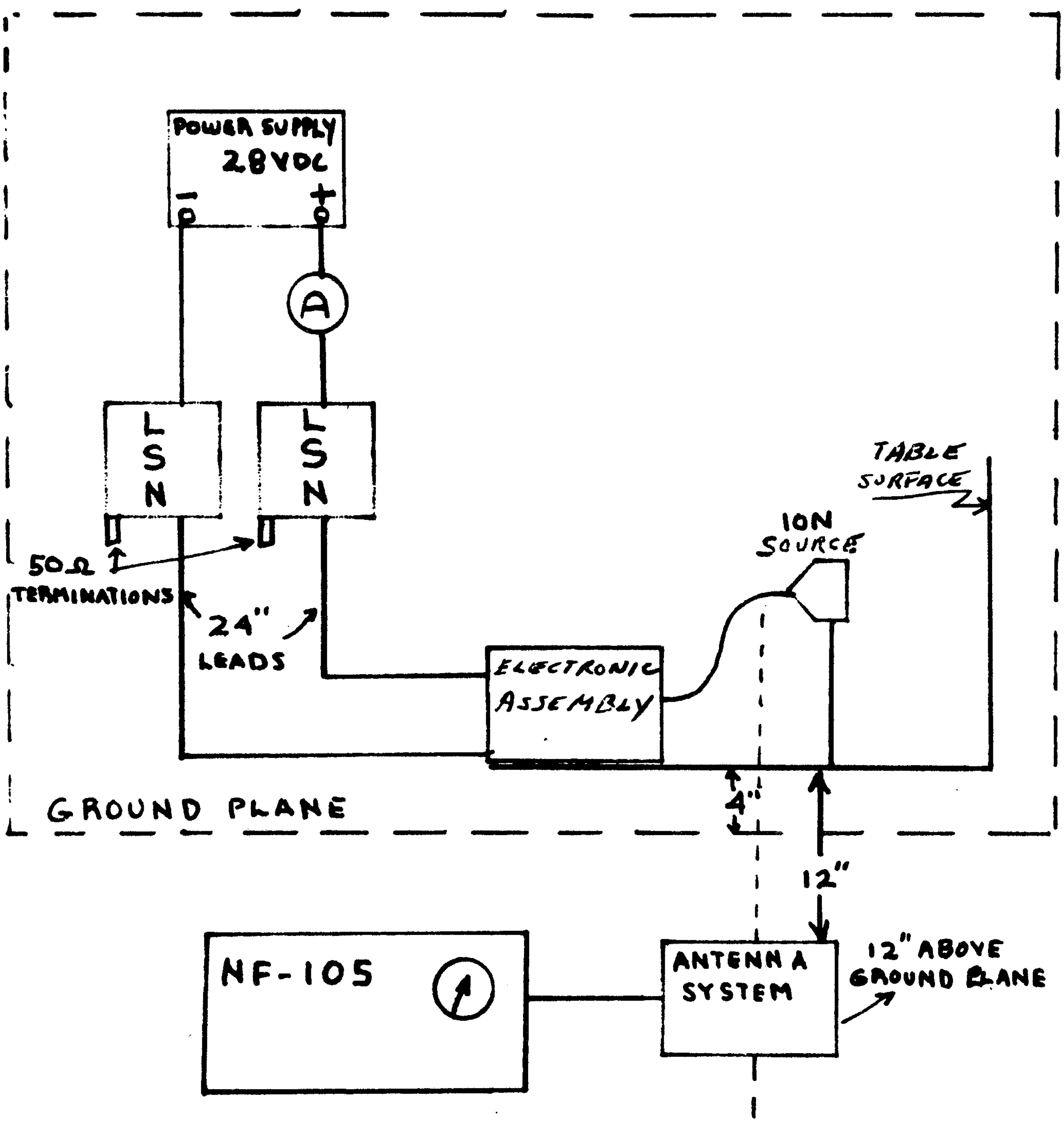


Figure 2. Radiated Interference Measurements, Test Configuration, (Frequency Spectrum 0.15 to 400 MHz)

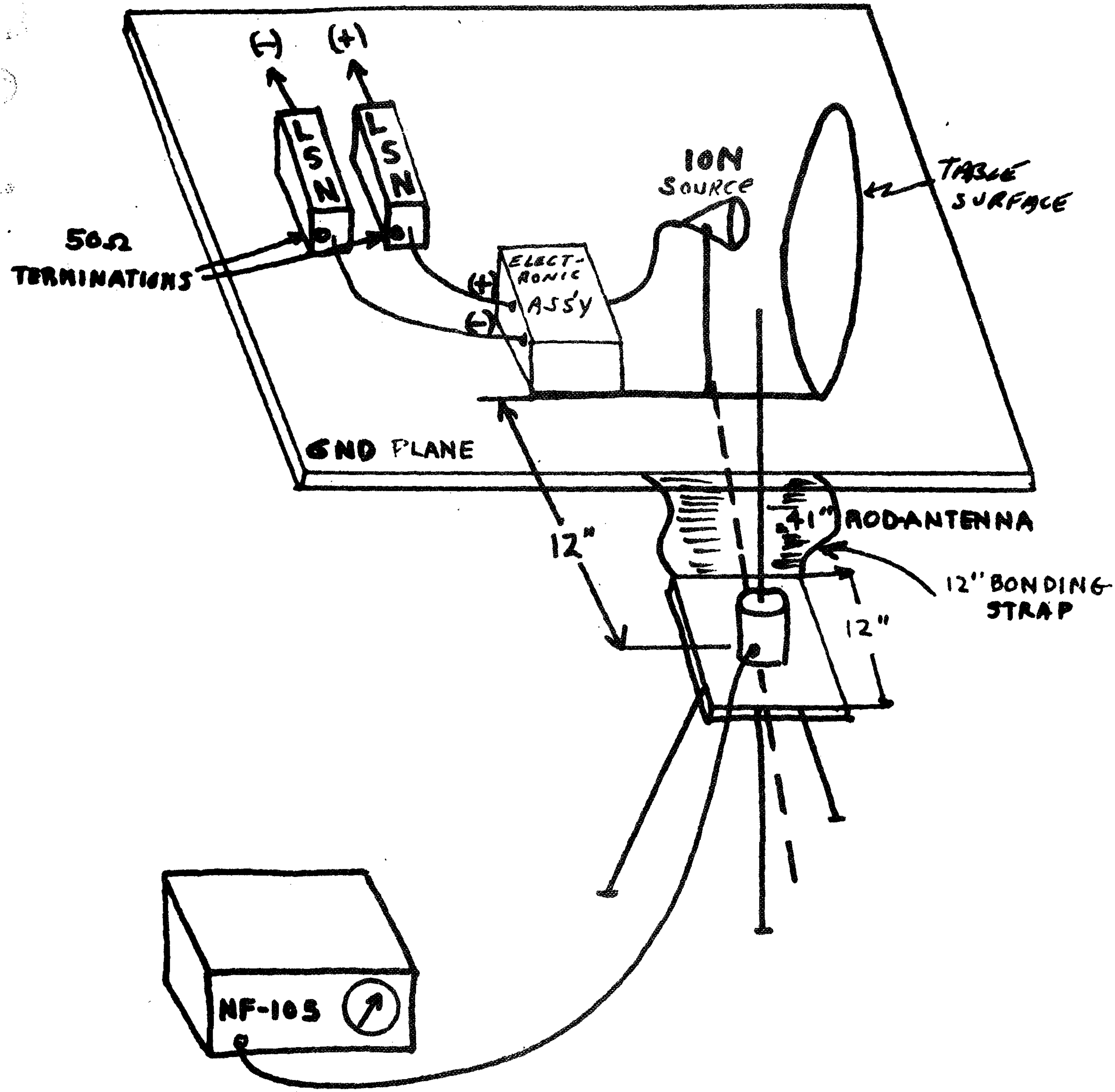


Figure 3. Antenna Configurations for the Frequency Range 0.15 to 30 MHz

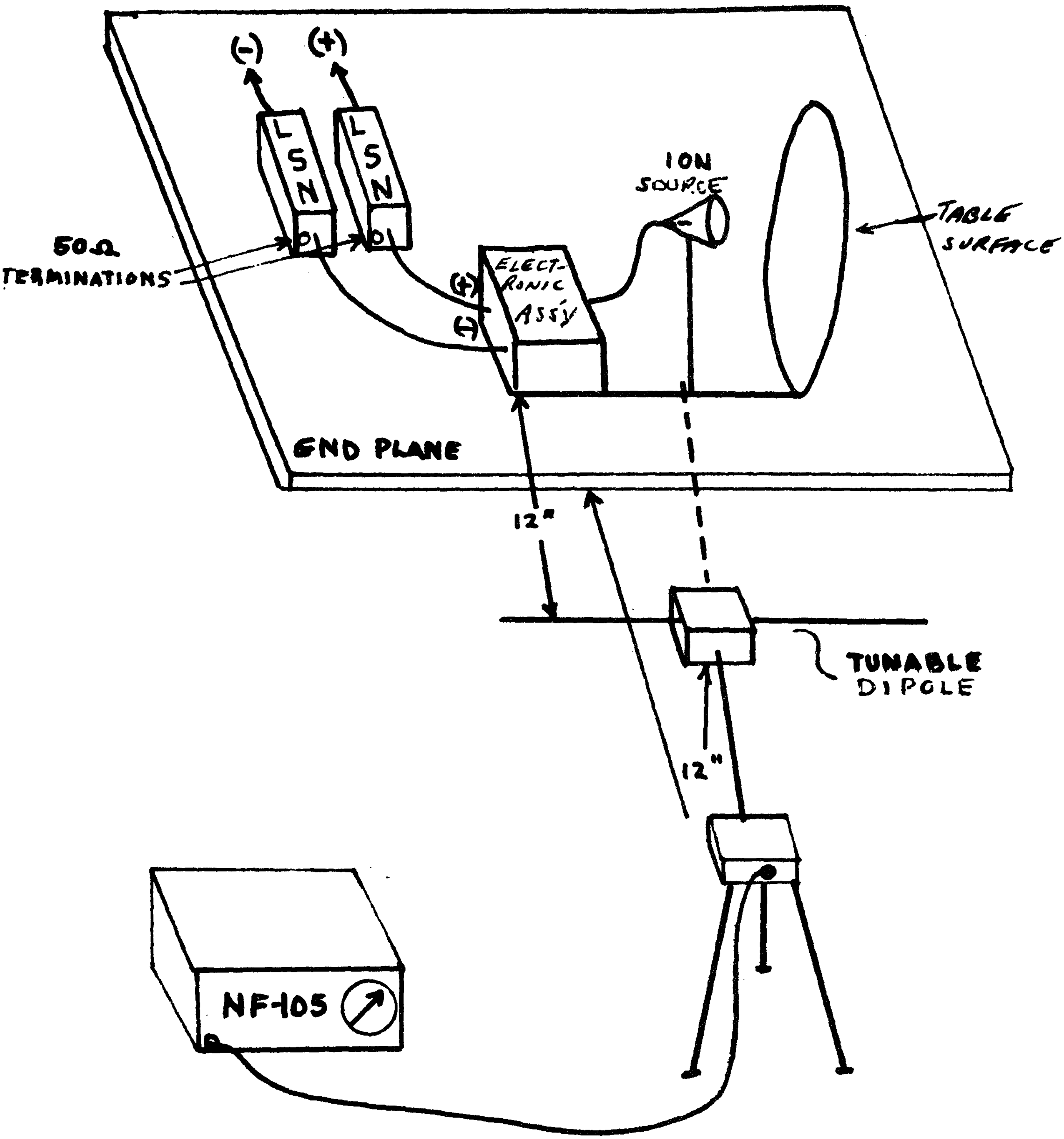


Figure 4. Antenna Configuration for Frequency Range 30 to 400 MHz

APPENDIX B

TO THE

ELECTROMAGNETIC INTERFERENCE TEST REPORT

(TEST DATA)

SPACE DIVISION CHRYSLER CORPORATION

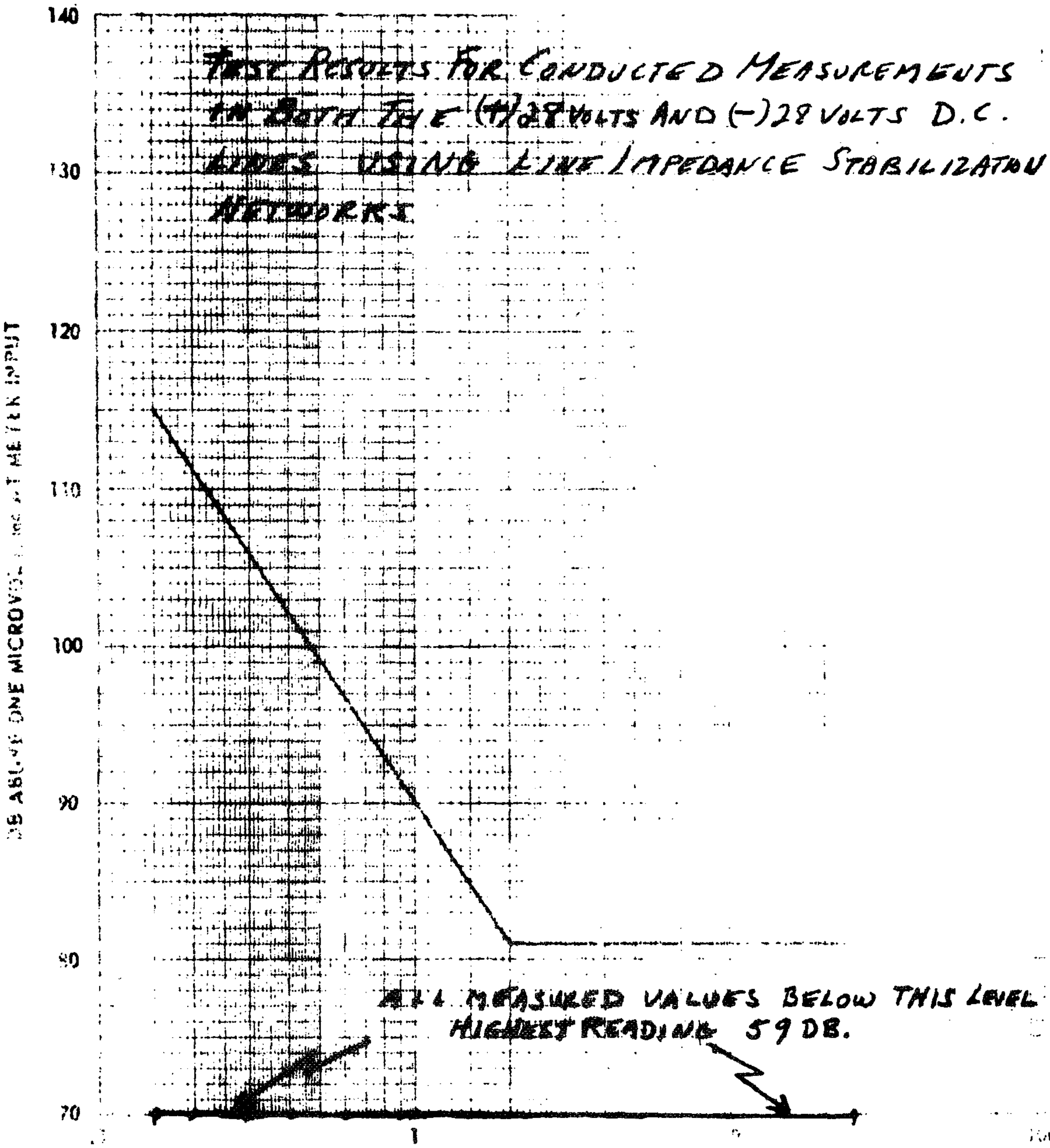
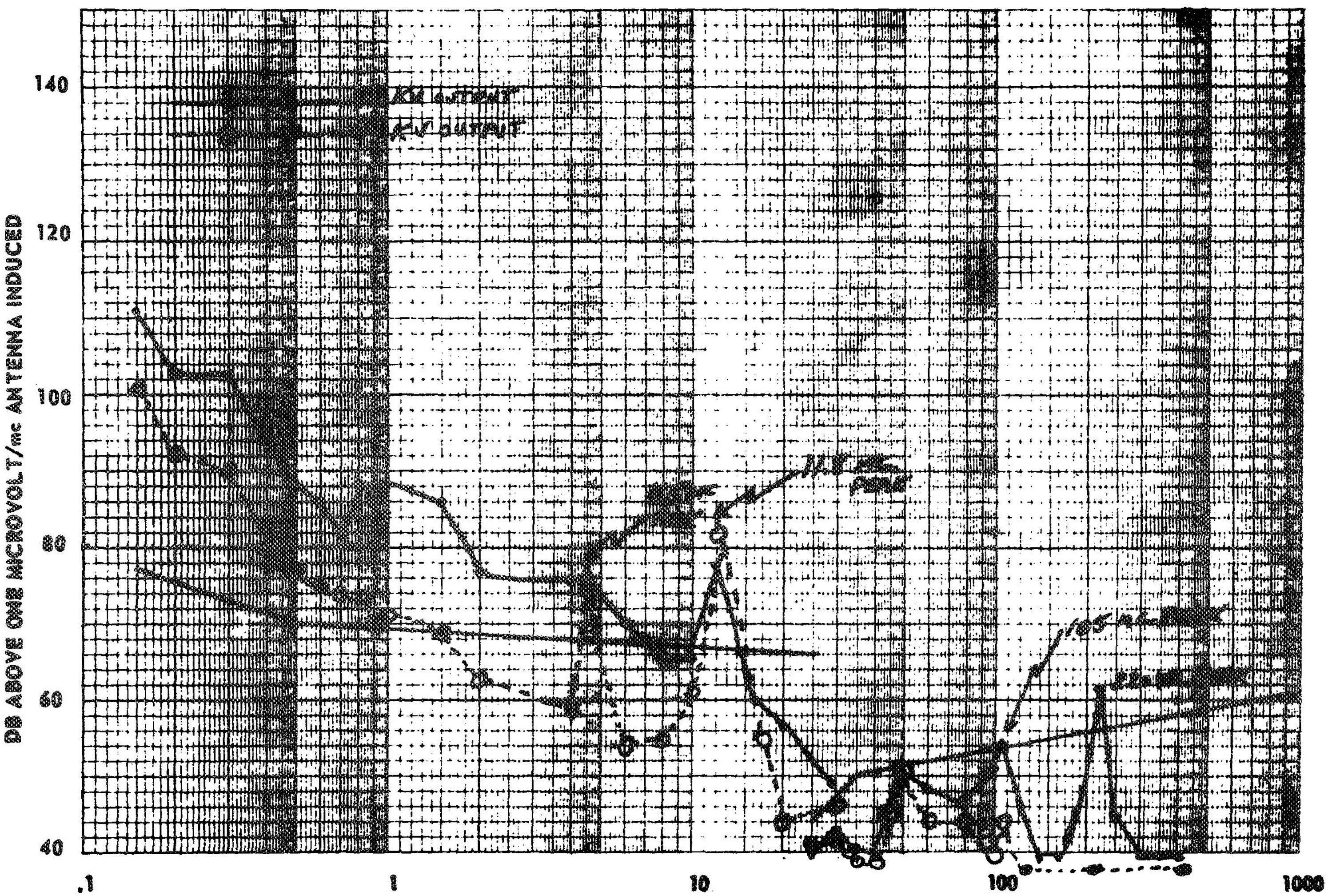


FIGURE 5

FREQUENCY (mc)

BROADBAND AND PULSED CW CONDUCTED INTERFERENCE LIMITS USING STABILIZATION NETWORK

EQUIPMENT TESTED GRAVITY SUBSTITUTE WORK BENCH S/N QUAL. UNIT MIL-I-6181D
MEASURING EQUIPMENT NF105 S/N 2314 LOCATION EMI. SHIELD ENCLOSURE
DATE OF LAST CALIBRATION 3/27/70 TEST DATE 8/27/70 TESTED BY E. LUKAWSKI.
WITNESSED BY NASA & Q.C. NOTES: 1. SEE TEST DATA SHEETS 1 AND 2
2. USED SUBSTITUTION METHOD OF MEASUREMENT



Page ____ of ____

EQUIPMENT TESTED GRAVITY SUBSTITUTE WORK BENCH S/N QUAL. UNIT

MEASURING EQUIPMENT NF105 S/N 2314

MIL-I-6181D

DATE OF LAST CALIBRATION 3/27/70 TEST DATE 8/27/70 TESTED BY E. LUKAWSKI LOCATION EMI. SHIELDED ENCLOSURE M.A.F.

WITNESSED BY NASA Q.C. AND CCSD. Q.C. NOTES: 1. SEE RFI TEST DATA SHEETS ~~3~~ 4

2. USED SUBSTITUTION METHOD OF MEASUREMENT

FIGURE 6

RFI DATA SHEET

Equipment Tested: ELECTROSTATIC WORKBENCH (Nomenclature) CHRYSLER CORP (Manufacturer) S/N QUAL. UNIT

Interference Measuring Equipment: NF105 S/N 2314

Date of Last Calibration: 3/27/70 Date of Test: 8/27/70 Type of Test: See note

Test Location: EMI SCREEN ROOM Test Conducted by: E. LUKAWSKI

NOTE: CONDUCTED BROADBAND INTERFERENCE SUBSTITUTION METHOD USING LINE STABILIZATION NETWORK IN (+) 28 V.D.C LEAD (LSN # 014419)

Test Freq (mc)	Type of Interference	Internal Noise ( )	Measured Level (DB/μV/MC)		Correction Factor ( )	Ambient Signal Level ( )	Spec Limit ( )	Signal Level ( )	Remarks
	POWER SUPPLY OUTPUTS →		40KV	20KV	-		SEE GRAPH	SAME AS MEASURED LEVEL	
0.15			59	60	-				
0.174			59	55					
0.198			59	55					
0.24			50	54	-				
0.29			54	54	-				
0.32			55	52					
0.36			53	46	-				
0.40			47	52					
0.60			49	51					
0.84			41	37					
0.90			40	36					
1.0			30	30					
2.0	noise level	27db	27	27	-				
4.0	"		25	25	-				
12.0	"		25	25	-				
25.0	"		24	24					
8.0	"								

TEST VERIFIED 8-28-70

CCSD C.K. [illegible]

NASA [illegible] 8-28-70

RFI DATA SHEET

Equipment Tested: ELECTROSTATIC WORKBENCH (Nomenclature) CHRYSLER CORP (Manufacturer) S/N QUAL. UNIT

Interference Measuring Equipment: NF105 S/N 2314

Date of Last Calibration: 3/27/70 Date of Test: 8/28/70 Type of Test: See note

Test Location: EMI SCREEN ROOM Test Conducted by: E. LUKAWSKI

NOTE: CONDUCTED BROADBAND INTERFERENCE SUBSTITUTION METHOD USING LINE STABILIZATION NETWORK IN (-) 28 V.D.C. LEAD (SN# 0M413)

Test Freq (mc)	Type of Interference	Internal Noise ( )	Measured Level (dbμv/mc)		Correction Factor (0)	Ambient Signal Level ( )	Spec Limit ( )	Signal Level ( )	Remarks
	Power Supply Output		40KV	20KV			SEE GRAPH		
0.15			54	58				SAME AS MEASURED LEVEL	
0.174			55	55					
0.198			58	54					
0.245			52	54					
0.29			52	50					
0.32			53	50					
0.36			51	45					
0.4			44	50					
0.6			45	49					
0.82			41	38					
0.9			39	37					
1.0			20	33					
2.0	(noise level 27db)		Below N	15E					
4.0			"	"					
8.0			"	"					
12.0			"	"					
25.0			"	"					

TEST VERIFIED 8-28-70

CCSD O.K. Johnson

NASA R. K. [illegible] 8-28-70

RFI DATA SHEET

Equipment Tested: ELECTROSTATIC WORKBENCH (Nomenclature) CHARKIER CORP (Manufacturer) S/N QUAL UNIT

Interference Measuring Equipment: NF 105 S/N 2314

Date of Last Calibration: 3/27/70 Date of Test: 8/28/70 Type of Test: See note

Test Location: EMI SCREEN ROOM Test Conducted by: E. LUKAWSKI

NOTE: "RADIATED" INTERFERENCE "BROADBAND" SUBSTITUTION METHOD USING 41" VERTICAL ANTENNA VA105

Test Freq (mc)	Type of Interference	Internal Noise ( )	Measured Level (db/mv/mc)		Correction Factor (db.)	Ambient Signal Level ( )	40KV ~~Spec Limit~~ LEVEL	20KV Signal Level ( )	Remarks
	Power Supply outputs →		40KV	20KV	FOR BOTH LEVELS		SIGNAL db/uv/mhz		
.15			74	64	37		111	101	
.20			67	56	36		103	92	
.31			66	53	37		103	90	
.40			64	53	30		94	83	
.5			56	45	32		88	77	
.6			53	42	33		86	75	
.7			48	40	34		82	74	
.8			54	39	34.5		88.5	73.5	
0.9			58	42	28.		86.	70.	
1.0 / 1.5			61 / 57	44 / 40	27.5 / ~~29~~ 29		88.5 / 86.0	71.5 / 69	
2.0			47	33	~~29~~ 30.		77.	68.	
4.0			51	34	25		76	~~63~~ 59	
6.0 / 4.5			52 / 50	50 / 34	25 / 20		77 / 70	75.0 / 54.0	← STRONG AUDIO TONE
8.0			46	36	19		65	55.	
10.0			45	40	20.5		65.5	60.5	
11.8			57	61	21.0		78.	82.	← STRONG AUDIO TONE
16.0			43	38	17.		60.	55.	
20.0			40	27	17.		57.	44.	
30.0			33	30	16.		49.	46	

TEST VERIFIED 8-28-70
CCSD OK Johnson
NASA R.L. Leyton 8-28-70

RFI DATA SHEET

Equipment Tested: ELECTROSTATIC WORKBENCH (Nomenclature) CHRYSLER CORP. (Manufacturer) S/N QUAL UNIT

Interference Measuring Equipment: NF. 105 S/N 2314

Date of Last Calibration: 3/27/70 Date of Test: 8/28/70 Type of Test: See note

Test Location: EME SCREEN ROOM Test Conducted by: E. LUKAWSKI

NOTE: RADIATED INTERFERENCE "BROADBAND" SUBSTITUTION METHOD USING ANTENNAS DM-105-T1 (20-200 MC'S) AND DM-105-T2 (200-400 MC'S)

Test Freq (mc)	Type of Interference	Internal Noise ( )	Measured Level (db/µv/mc)		db Correction Factor (FOR-BOTH)	Ambient Signal Level ( )	SIGNAL LEVEL ~~Spec Limit~~ (40KV)	Signal Level (20KV)	Remarks
	Power Supply outputs →		40KV	20KV			db/mv/mhz antenna induced		
25			30	32	8.2		38.2	40.2	
30			35	33	8.3		43.3	41.3	
35			32	27	8.3		40.3	35.3	
40			30	28	8.4		38.4	36.4	
60			40	35	8.6		48.6	43.6	
80			38	35	8.8		46.8	43.8	
100			42	30	9.0		51.0	39.	
105			45	35	9.1		54.1	44.1	← GOES TO 44.1 WITH REDUCTION OF CORONA
140	(NOISE LEVEL 27db) BELOW		NOISE -		9.3		—	—	
160			"	"	9.4		—	—	
200			46	"	9.6		55.6	—	
220			52	"	9.7		61.7	—	← GOES TO NOISE LEVEL WITH REDUCTION OF CORONA.
250			35	"	9.9		44.9	—	
300			NOISE LEVEL		10.1		—		
330			"	"	10.2		—	—	
400			"	"	10.5		—	—	
								—	
46			37	36	8.5		45.5	44.5	
49			42	42	8.5		50.5	50.5	

TEST VERIFIED 8-28-70

CCSD C K Johnson

NASA [illegible] 8-28-70

DATA SHEET NO. 2-2

DATE OF TEST 9-1470

TEST BY E.D.

UNIT QUAL

(PRIOR TO RFI RADIATED RETEST)

ELECTROADHESIVE FORCE MEASUREMENT

Ref. Para. 3.3.2

9-14-70

INITIAL TABLE ORIENTATION $d_o = 14.0$; $D = d_B - d_o$

S2 POS.	HEAD NO.	TABLE CURRENT I_T (mA)	LEAKAGE CUR. I_L (mA)	SUPPLY CURRENT I_{HS} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	.156	2.16		21.5	7.5	32.8	31.9
	2	.136	2.00		22	8.0	39.5	
	3	.146	2.03		21	7.0	27.8	
	4	.155	1.98		21	7.0	27.8	
3	1	.070	.98		19.75	5.75	19.4	17.8
	2	.090	1.2		19.	5.0	15.8	
	3	.035	.95		19.5	5.5	18.1	
	4	.035	1.0		19.5	5.5	18.1	
2	1	.021	.080		17.5	3.5	10.2	13.7
	2	.021	.090		18.5	4.5	13.8	
	3	.021	.090		18.25	4.25	12.8	
	4	.021	.091		19.5	5.5	18.1	
1	1	.008	0.0		16.0	2.0	5.6	5.6
	2	.008	0.0		16.0	2.0	5.6	
	3	.009	0.0		16.0	2.0	5.6	
	4	.009	0.0		16.25	2.25	6.3	

ORIENT TABLE 180° $d_o =$ [illegible]

S2 POS.	HEAD NO.	TABLE CURRENT I_T (mA)	LEAKAGE CUR. I_L (mA)	SUPPLY CURRENT I_{HS} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	.14	2.1		[illegible]	6.8	25.8	27.3
	2	.12	[illegible]		[illegible]	6.3	17.0	
	3	.12	[illegible]		[illegible]	6.0	20.8	
	4	.14	[illegible]		[illegible]	7.8	35.8	
3	1	.06	[illegible]		[illegible]	6.6	18.7	19.7
	2	.06	1.0		[illegible]	5.3	16.9	
		[illegible]	[illegible]		[illegible]	6.0	20.8	
		[illegible]			[illegible]	6.3	22.3	

DATA SHEET NO. 2-3
DATE OF TEST 9-14-70
TEST BY ECB
UNIT QUAL

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED)

Ref. Para. 3.3.2

9-14-70

ORIENT TABLE 180°

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{HS} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1	0.020	[illegible]		16.5	2.8	7.8	9.2
	2	0.020	0.14		17.0	3.3	9.4	
	3	[illegible]	[illegible]		17.0	3.3	9.4	
	4	0.123	0.065		17.2	3.5	10.2	
1	1	0.017	0.004		14.0	.3	0.7	0.17
	2	[illegible]	[illegible]		[illegible]	0	0	
	3	0.016	[illegible]		[illegible]	0	0	
	4	0.017	[illegible]		[illegible]	0	0	

S-2 POS	AVG FORCE
4	29.6
3	18.8
2	11.5
1	2.89

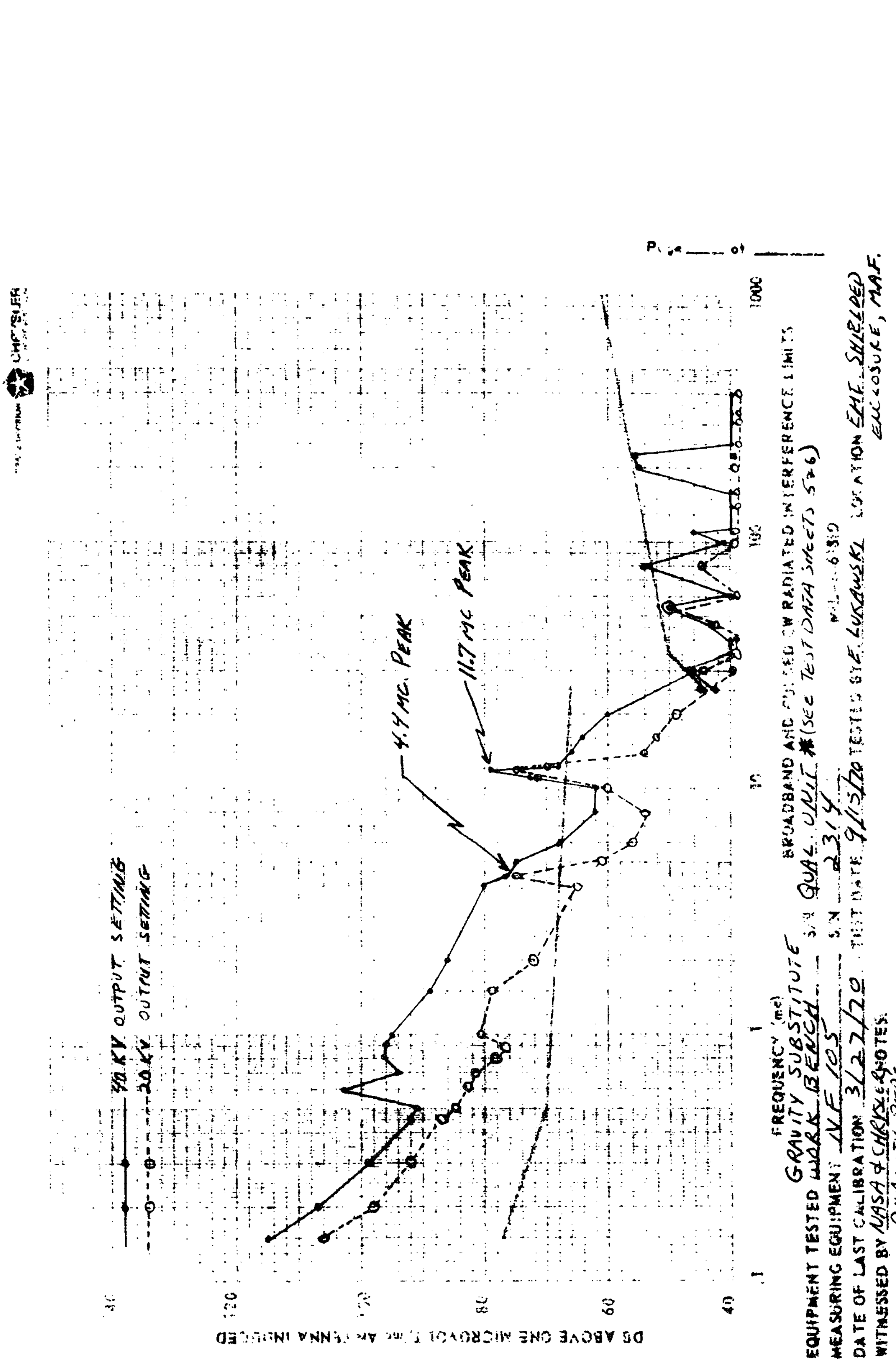

40 KV OUTPUT SETTING
20 KV OUTPUT SETTING
4.4 MC. PEAK
11.7 MC PEAK
DB ABOVE ONE MICROVOLT PER MC ANTENNA INDUCED
40
60
80
100
120
.1
1
10
100
1000
FREQUENCY (mc)
Page ___ of ___
BROADBAND AND PULSED CW RADIATED INTERFERENCE LIMITS
EQUIPMENT TESTED WORK BENCH GRAVITY SUBSTITUTE
S/N QUAL UNIT * (SEE TEST DATA SHEETS 5 & 6)
MEASURING EQUIPMENT NF 105
S/N 2314
DATE OF LAST CALIBRATION 3/27/70
TEST DATE 9/15/70
TESTED BY E. LUKAWSKI
LOCATION EMI SHIELDED ENCLOSURE, MAF.
WITNESSED BY NASA & CHRYSLER QUALITY REPS.
NOTES

FIGURE 7

RFI DATA SHEET

Equipment Tested: ELECTROSTATIC WORK BENCH (Nomenclature) CHRYSLER CORP. (Manufacturer) S/N QUAL. UNIT *

Interference Measuring Equipment: NF 105 S/N 2314

Date of Last Calibration: 3/27/70 Date of Test: 9/15/70 Type of Test: See NOTE

Test Location: EME SCREEN ROOM Test Conducted by: E. LUKAWSKI

NOTE: "RADIATED" INTERFERENCE "BROADBAND" SUBSTITUTION METHOD USING 41" VERTICAL ANTENNA. VA105

* BLEED COVER REPLACED; PROTOTYPE TABLE TOP INSTALLED

Test Freq (mc)	Type of Interference	Internal Noise ( )	Measured Level (db/μv/mhz)		Correction Factor (db)	Ambient Signal Level ( )	40KV ~~Spec Limit~~ ( )	20KV Signal Level ( )	Remarks
	POWER SUPPLY	OUTPUTS →	40KV	20KV	FOR BOTH LEVELS		SIGNAL LEVELS DB/μV/mhz		
.15			78	69	37		115	106	SPREADER PEAKS
.20			71	62	36		107	98	"
.30			62	55	37		99	92	"
.45			62	57	30		92	87	"
.50			59	53	32		91	85	"
.60			70	50	33		103	83	"
.70			60	48	34		94	82	"
.80			62	44	34.5		96.5	78.5	"
.90			68	49	28		96	77	"
1.0			68	53	27.5		95.5	80.5	"
1.5			60	50	29.0		89	79.	"
2.0			56	42	30.		86	72	"
4.0			55	40	25.		80	65	"
4.4			52	50	25.		77	75	"
5.0			50	36	25.		75	61	"
6.0			48	36	20.		68	56	"
8.0			43	35	19.		62	54	"
10.0			41	39	20.5		61.5	59.5	"
11.4			52	51	21.		73	72	"
11.7			58	54	21.		79	75	TONE MODULATED
12.0			47	49	21.		68	70	
14.0			47	35	19.		66	54	
16.0			47	35	17.		64	52	
20.0			43	32	17.		60	49	
30.0			30	NOISE	16.		46	—	
	TEST VERIFIED		9/15/70						
	CCSD R. [illegible] Q.C.			NASA [illegible]				9-15-70	

RFI DATA SHEET

Equipment Tested: ELECTROSTATIC WORKBENCH (Nomenclature) CHRYSLER CORP (Manufacturer) S/N QUAL UNIT *

Interference Measuring Equipment: N.F. 105 S/N 2314

Date of Last Calibration: 3/27/70 Date of Test: 9/15/70 Type of Test: SEE NOTE

Test Location: EMI SCREEN ROOM Test Conducted by: E. LUKAWSKI

NOTE: RADIATED INTERFERENCE "BROADBAND" SUBSTITUTION METHOD USING ANTENNAS DM-105-T1 (20-200MC'S) AND DM-105-T2 (200-400MC'S)

* BLEED COVER REPLACED; PROTOTYPE TABLETOP INSTALLED

Test Freq (mc)	Type of Interference	Internal Noise ( )	Measured Level (db/mv/mhz)		db. Correction Factor (FOR BOTH)	Ambient Signal Level ( )	SIG. LEVEL ~~Spec Limit~~ (40KV)	Signal Level (20KV)	Remarks
	Power Supply outputs →		40KV	20KV			db/mv/mhz antenna induced		
25			34	37	8.2		42.2	45.2	
30			37	36	8.3		45.3	44.3	
35			27	24	8.3		35.3	32.3	
40			24	25	8.4		32.4	33.4	
46			35	34	8.5		43.5	42.5	
52			41	41	8.5		49.5	49.5	
60			26	25	8.6		34.6	33.6	
80			46	36	8.8		54.8	44.8	
100			32	26	9.0		41.	35.	
105			37	26	9.1		46.1	35.1	
140			27	26	9.3		36.3	35.3	
160			27	24	9.4		36.4	33.4	
200			45	28	9.6		54.6	37.6	
220			46	24	9.7		55.7	33.7	
250			24	24	9.9		34.	34.	
300			26	22	10.1		36.1	32.1	
330			22	22	10.2		32.2	32.2	
400			23	23	10.5		33.5	33.5	

TEST VERIFIED 9/15/70
CCSD: [illegible] QC
NASA [illegible] 9/15/70

APPENDIX B

QUALIFICATION TEST SPECIFICATIONS AND PROCEDURES

for an

ELECTROSTATIC GRAVITY SUBTITUTE WORKBENCH

QUALIFICATION TEST SPECIFICATIONS AND PROCEDURES

FOR

ELECTROSTATIC GRAVITY SUBSTITUTE WORKBENCH

NASA DRAWING NUMBER 95M12015

INTENDED FOR USE IN

SKYLAB EXPERIMENT M507

CONTRACT NAS8-21385

APPROVED: P. S. Theobald 7/22/70
PROJECT SUPERVISOR

APPROVED: J. B. Kendall 8/20/70
PRINCIPAL INVESTIGATOR

PREPARED BY

CHRYSLER CORPORATION SPACE DIVISION

P. O. BOX 29200 NEW ORLEANS, LA. 70129

CONTENTS

CONTENTS

ILLUSTRATIONS

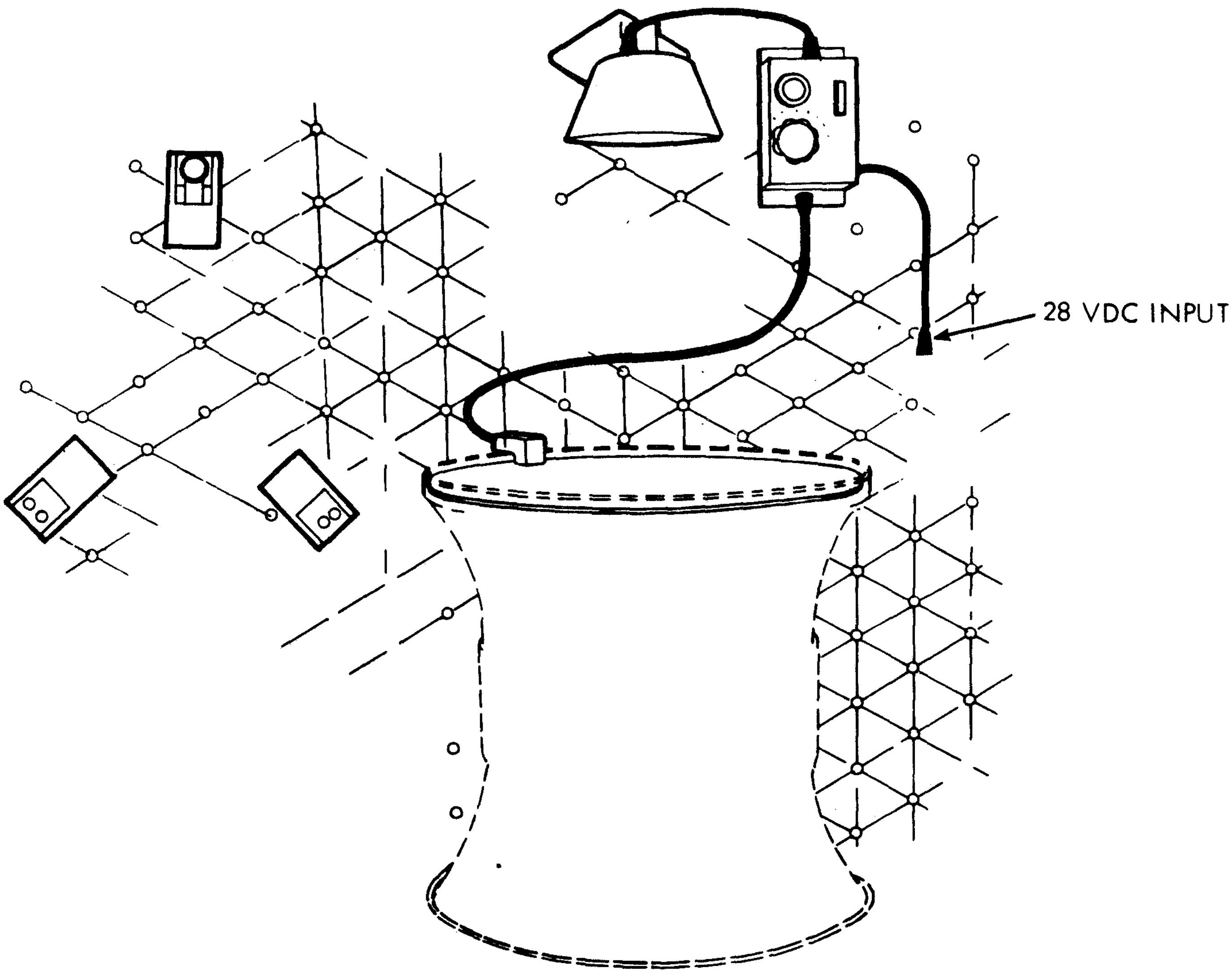


Figure 1. Gravity Substitute Workbench (Electrostatic) shown in Operational Configuration in Workshop

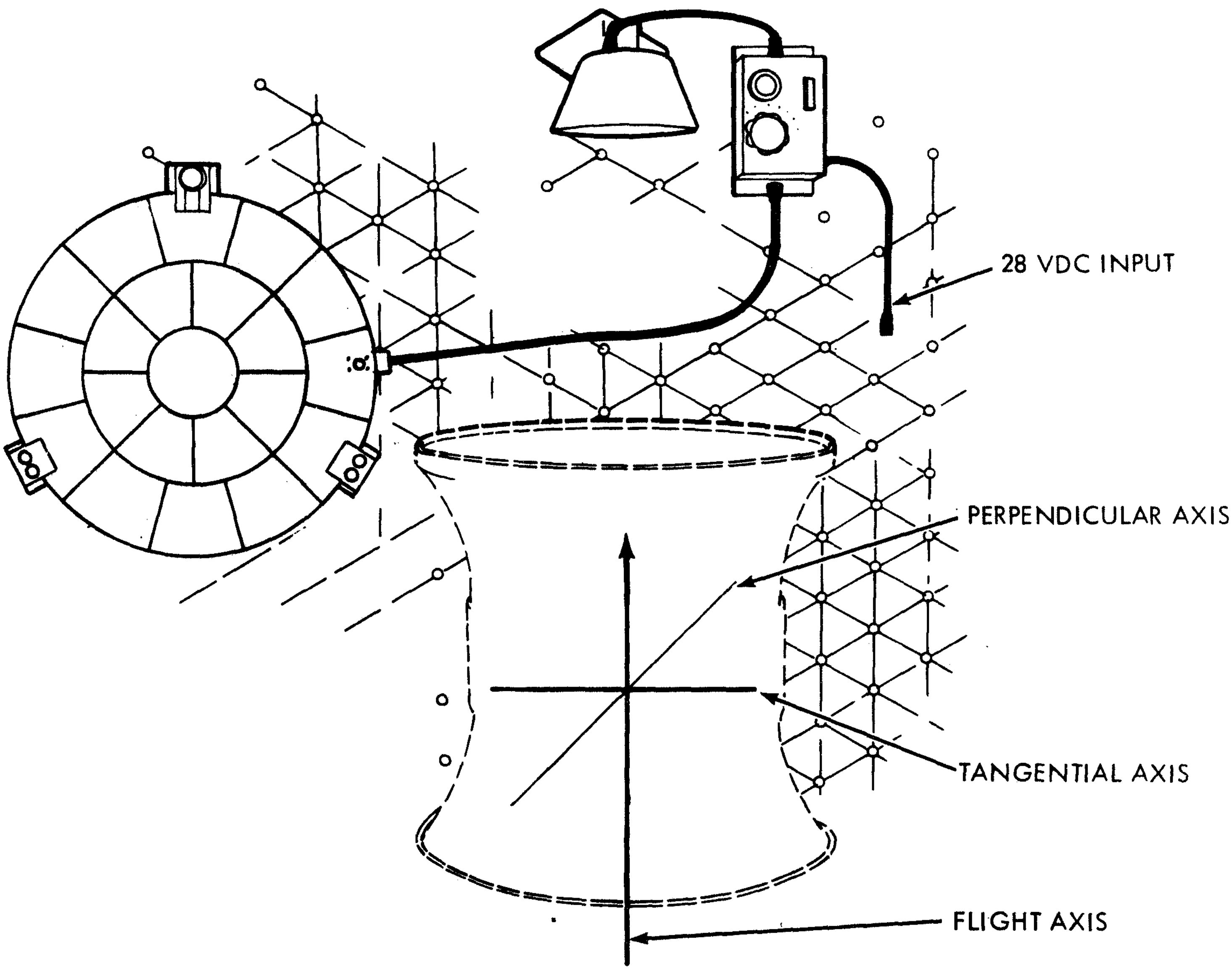


Figure 2. Gravity Substitute Workbench (Electrostatic) shown in Stored Configuration in Workshop

1. Scope

1.1 This document presents the test specifications and procedures required to establish qualification of the Electrostatic Gravity Substitute Workbench (EGSW) for use in the Skylab Experiment M507. The EGSW is intended to be installed on a "space-grid" wall, adjacent to the ward room in the crew quarters of the orbital workshop. This wall is a radial segment located between positions 3 and 4 and between NASA stations 2896.516 and 2975.050.

2. APPLICABLE DOCUMENTS

2.1 The following documents are either listed as references to indicate the primary sources used for preparation of this document, or form a part of this document by virtue of the applicability as specified herein. Unless otherwise indicated, the issue in effect on the date of the tests shall apply.

SPECIFICATIONS

Military

MIL-E-5272	Environmental Testing, Aeronautical and Associated Equipment, General Specification for.
MIL-E-6051C	System Compatibility and Interference Control Requirements for Aircraft Equipment
MIL-I-6181D	Interference Control Requirements, Aircraft Equipment

National Aeronautics and Space Administration (NASA)

Not Numbered	Experiment General Specification for Hardware Development (Office of Manned Space Flight)

George C. Marshall Space Flight Center (MSFC)

Not Released	End Item Specification, Performance/Design (Part I) Requirements, M507 Gravity Substitution Workbench for Apollo Applications Program (AAP)
RS003M00003	Performance and Design Integration Requirements for Cluster System/Apollo Applications Program, General Specification for

George C. Marshall Space Flight Center (MSFC) continued

ERD-M507	Experiment Requirements Document for Gravity Substitution Workbench (Experiment M507)
MSFC-SPEC-101	Flammability Requirements and Test Procedures for Material in Gaseous Oxygen Environments

STANDARDS

Military

MIL-STD-810B	Environmental Test Methods for Aerospace and Ground Equipment

PROCEDURES

MSFC

MSFC-PROC-151	Contamination Control and Environmental Protection of Space Launch Vehicles

PUBLICATIONS

NASA

NPC 200-2	Quality Program Provisions for Space System Contractors
NHB 5300.5	Apollo Applications Reliability and Quality Assurance Program Plan
NHB 8080.3	Apollo Applications Test Requirements

Manned Spaceflight Center (MSC)

MSC-D-NA-0002	Procedure and Requirements for the Flammability and Offgassing Evaluation of Manned Spacecraft Nonmetallic Materials

MSFC

IN-ASTN-AD-70-1	Preliminary Vibration, Acoustic, and Shock Specifications for Components on Saturn V Workshop
50M02442	ATM Material Control for Contamination due to Outgassing

(Copies of specifications, standards, procedures, and publications required in connection with qualification tests should be obtained from the Apollo Applications Program Office.)

3. REQUIREMENTS

3.1 General. The EGSW shall be tested for qualification to the environmental levels specified in this document. Qualification test hardware shall be identical in configuration to hardware used in flight and shall be subjected to testing identical to the acceptance tests performed on flight hardware prior to initiation of qualification testing. The assembly shall perform its intended operational functions during or after exposure to these environmental conditions. The EGSW identified as the Qualification Unit shall be subjected to qualification testing as specified herein. Testing shall be conducted at the highest possible level of assembly. Lower level testing shall be completed prior to performance of tests on hardware at higher levels of assembly.

3.2 Test conditions. - Unless otherwise specified herein or in the equipment specification, all tests and measurements shall be performed at 23 $\pm$ 10 degrees Celsius (°C), 28.5 $\pm$ 4.5 inches of mercury (Hg), and 50 $\pm$ 30 percent relative humidity.

3.3 Determination of failure. A specimen shall be considered as having failed the test if the specimen malfunctions (see para. 4.1) during or after any of the tests or reveals structural damage in post test inspection. All test failures shall be reported immediately to the experiment principal investigator and processed in accordance with paragraph 4.1. Nonconformances that occur during testing must be resolved before proceeding with previously planned, scheduled tests; however, specific tests aimed at resolving the anomaly may be conducted.

3.4 Mounting of test specimen. - The test specimen shall be mounted in a manner simulating the actual mounting in the flight vehicle for all qualification tests. The Force Test Fixture shall be used for the Temperature, and Altitude Tests. For the Vibration Test, see para. 3.7. Mounting for the Electromagnetic Interference Test is described in Appendix II, para. 4.2.

3.5 Test Equipment - The test equipment specified herein, or equivalent, shall be provided for the performance of the required tests. The environmental test equipment shall be capable of producing and maintaining the required test conditions. All inspection, measuring, and test equipment shall be calibrated and maintained in accordance with Chrysler Corporation Space Division Procedure No. SD-10H.

Equipment	Make and Model	Serial No.
Temp./Alt. Chamber	Conrad FH-125-10-20	200394
Vibration System	MB C210	200384
Accelerometer	Endevco 2220	95-1481B

Equipment	Make and Model	Serial No.
Accelerometer	Endevco 2220	95-1129B
Accelerometer	Endevco 2220	018355B
Temperature Recorder	Honeywell	2009224
Counter	CMC 726B	017541
Multimeter	Simpson 260	95-1671B
Megohmeter	General Radio 1862-B	104672
Ammeter	Weston 931	95-1135B
Electrostatic Voltmeter	Singer ESH	945827
Force Test Fixture	CCSD	N/A

Electromagnetic Interference peculiar equipment - see Appendix II.

3.6 Test facilities. - Test facilities shall meet the requirements of the individual qualification test procedure.

3.7 Fixture for dynamic testing. - The fixture design shall minimize fixture response within the test frequency range. The fixture shall support the specimen in a manner simulating vehicle installation. The fixture design and specimen installation should be approved by a qualified dynamics engineer prior to the start of testing.

3.8 Test responsibilities. - All tests shall be performed at the Michoud Assembly Facility by the Chrysler Corporation Space Division Test and Evaluation Laboratory. The procedures as described in this document shall be performed under the cognizance of the Project Supervisor for this program.

3.9 Measurement tolerances.

3.9.1 Electrical. - Unless otherwise specified, the electrical measurement tolerances shall be as follows:

(a) Primary voltage: ± 0.5 percent

(b) Primary current: ± 5.0 percent

(c) Radio frequency (RF) power: ± 5.0 percent

(d) Carrier frequency: ± 0.5 Megahertz (MHz)

(e) Time: ±2.0 percent

3.9.2 Environmental. - Unless otherwise specified, the environmental measurement tolerances shall be as follows:

(a) Temperature: ±2.0°C

(b) Pressure:

(1) Atmospheric (ambient): ±5.0 percent

(2) Vacuum: ±10.0 percent

(c) Time: +10.0 percent
− 0.0 percent

(d) Vibration:

(1) Overall root mean square acceleration (grms) ±10.0 percent

(2) Acceleration power spectral density (g^2/Hz) (Based on analyzers having 25 Hz bandwidths or less) +100.0 percent
-30.0 percent

(3) Sinusoidal acceleration +20.0 percent
-10.0 percent

(4) Frequency ±5.0 percent

(5) Test duration +10.0 percent
-0.0 percent

3.10 Test sequence. - The test sequence shall be as follows:

(a) Electromagnetic interference

(b) Temperature

(c) Altitude

(d) Vibration

3.11 Visual inspection. Prior to commencing and after completion of each qualification test, the EGSW hardware shall be visually inspected for completeness; physical defects such as warpage, discoloration, breakage, loose pieces, cracks, etc.; and setting and position of controls, fasteners, etc. If necessary, the test specimen shall be disassembled after testing is completed and inspected to determine margins of safety and potential failure modes.

3.12 Log books. - Log books shall be maintained on the EGSW qualification tests specified in this document. They shall contain all data pertinent to visual inspections, functional tests, operating time, failures and their resolutions, and any other significant anomalies observed during this testing.

3.13 Functional test requirements. Mechanical and electrical functional tests shall be conducted prior to and subsequent to each environmental test as required to determine the effects of the environment upon those equipment parameters which could be affected by the test environment. The tests shall be identical to the corresponding functional testing portions of the end item acceptance test procedure for flight hardware. The performance during the acceptance tests conducted prior to initiation of the qualification test shall be the baseline for comparison of performance during the qualification tests. Failure to pass the functional test requirements shall constitute failure (see para. 3.3) of the qualification test hardware. Functional test procedures shall be approved by the experiment principal investigator.

3.14 Cleanliness. - The internal and external surfaces of the experiment shall be cleaned in accordance with MSFC-SPEC-164. Maintenance of cleanliness levels and environmental protection of external surfaces shall be in accordance with MSFC-PROC-151.

3.15 Qualification test requirements and procedures.

3.15.1 Electromagnetic interference. - The EGSW shall be subjected to electromagnetic interference testing in accordance with specification MIL-I-6181D. The test procedure shall be prepared and the tests performed by the Chrysler Corporation Space Division EMI Unit personnel. Tests shall be performed to determine conducted interference,radiated interference, and susceptibility to conducted interference. (See Appendix II for test procedure.)

3.15.2 Temperature. - The EGSW shall be tested for resistance to temperature extremes over a long period of time as follows:

(a) Place the EGSW in a temperature chamber at ambient conditions in such a position that the heating or cooling medium will not impinge directly upon the test specimen during the tests.

(b) At ambient conditions, connect the test setup and perform a functional test in accordance with Appendix I paragraph 3.3.1 & 3.3.2 and record data.

(c) Lower the chamber temperature at a rate of 10°F each five (5) minutes until the temperature has reached minus

(c) continued

50°F. Stabilize and maintain the chamber (test specimen not operating) at this temperature for a minimum of seventy-two (72) hours.

(d) Return the chamber temperature to ambient conditions at the rate of 10°F each five (5) minutes and allow the EGSW to stabilize for a minimum of sixty (60) minutes. Repeat the functional test as above and record data.

(e) Raise the chamber temperature at the rate of 10°F each five (5) minutes until the temperature has reached 160°F. Stabilize and maintain the chamber (test specimen not operating) at this temperature for a minimum of forty-eight (48) hours. Maintain a relative humidity of not more than 15 percent in the test chamber throughout the exposure period.

(f) Return the chamber temperature to ambient conditions at the rate of 10°F each five (5) minutes and allow the EGSW to stabilize for a minimum of sixty (60) minutes. Repeat the functional test as above and record data.

(g) Perform a visual inspection for any damage resulting from the test and document in detail any physical damage or change in functional performance.

3.15.3 Altitude - The EGSW shall be tested for indications of changes in dielectric constant of materials, high voltage problems, decrease in heat transfer from the power supply, and other changes in operating characteristics in a low pressure environment as follows:

(a) Place the assembly in an altitude chamber at ambient conditions. Connect the test setup and perform a functional test in accordance with Appendix I, paragraph 3.3.1 and 3.3.2 and record data.

(b) During the altitude test, record but do not control the chamber internal temperature. The EGSW shall remain inoperative. Gradually reduce the chamber pressure to 10^{-4} mm of mercury and maintain for a minimum of 6 hours.

(c) After the EGSW has been exposed for the required time at minimum pressure, gradually increase the chamber pressure to 258 mm of mercury.

(d) Within one hour of reaching this new condition, apply power to the EGSW with the voltage selector switch in position 4 and monitor the temperature of the power supply by means of a thermocouple or other temperature sensor. (Make provisions to prevent the power supply maximum operating temperature from being exceeded).

(e) After one (1) hour of operation with power on, perform a functional test in accordance with Appendix I paragraph 3.3.1 and 3.3.2 (except that the table orientation shall be checked in one position only), at reduced pressure and record data. Record the power supply temperature.

(f) After completion of the reduced pressure test, turn off the EGSW power and gradually return the pressure chamber to ambient conditions.

(g) Within one (1) hour of reaching ambient conditions, repeat the functional test in accordance with Appendix I paragraph 3.3.1 and 3.3.2 and record data.

(h) Perform a visual inspection for any damage resulting from the test and record any evidence of arcing or breakdown during exposure to reduced pressure or any change in functional performance.

3.15.4 Vibration - The EGSW shall be tested for the effects of vibration on component parts. The EGSW shall remain inoperative (power off) during vibration. The vibration test shall be conducted in three parts and in the sequence shown:

1. Vehicle Dynamics Test

2. Sinusoidal Evaluation Test

3. Random Vibration Test

Mount the control accelerometer(s) on the test fixture at the point(s) where the specimen or supporting bracketry attaches to the test fixture.

(a) Mount the EGSW on a rigid fixture capable of orienting the test assembly relative to the applied force in the axes specified in Figure 2. Install the fixture on the vibration table and perform a functional test on the EGSW in accordance with Appendix I paragraph 3.3.1 and record data.

(b) At the conclusion of each period of vibration (in each axis) repeat the functional test as above and record data. Perform a visual inspection for any damage resulting from the test and document any physical damage or change in functional performance.

3.15.4.1 <u>Vehicle Dynamics Criteria</u> - Test levels are stated below. Sweep the specified frequency spectrum logarithmically at the rate of three (3) octaves per minute in the three axes at the following levels:

<u>Flight Axis</u>

3 to 7 Hz @ 0.43 inches D.A. displacement

7 to 14 Hz @ 1.1 g's peak

14 to 25 Hz @ 0.11 inches D.A. displacement

25 to 60 Hz @ 3.6 g's peak

<u>Lateral Axes</u>

2.0 to 4.0 Hz @ 0.34 inches D. A. displacement

4.0 to 7.0 Hz @ 0.28 g's peak

7.0 to 20 Hz @ 0.08 g peak

3.15.4.2 <u>Sinusoidal Evaluation Criteria</u> - Sweep the frequency spectrum logarithmically at the rate of one (1) octave per minute in the three axes at the following level:

<u>All Axes</u>

20 to 100 Hz @ 0.0020 inches D.A. displacement

100 to 2000 Hz @ 1.0 g peak

3.15.4.3 <u>Lift-off Random Vibration Criteria</u> - Impose the test levels listed below for one (1) minute per axis.

<u>Flight Axis</u>

20 to 30 Hz @ 0.10 g^2/Hz

30 to 1000 Hz @ -3dB/oct

1000 to 2000 Hz @ 0.0030g^2/Hz   Composite = 4.1 grms

<u>Tangential to Wall</u>

20 to 100 Hz @ 0.10g^2/Hz

100 to 2000 Hz @ -3dB/oct

2000 Hz @ 0.005g^2/Hz   Composite = 6.2 grms

Perpendicular to Wall

20 to 100 Hz @ -3dB/oct

100 to 2000 Hz @ $0.0060g^2$/Hz Composite = 3.5 grms

3.15.4.4 Boost Random Vibration Criteria - Impose the test levels listed below for two (2) minutes per axis.

Flight Axis

20 to 30 Hz @ $0.025g^2$/Hz

30 to 1000 Hz @ -3dB/oct

1000 to 2000 Hz @ $0.00070g^2$/Hz Composite = 1.9 grms

Tangential to Wall

20 to 100 Hz @ $0.025g^2$/Hz

100 to 2000 Hz @ -3dB/oct

2000 Hz @ $0.0012g^2$/Hz Composite = 3.1 grms

Perpendicular to Wall

20 to 2000 Hz @ $0.0075g^2$/Hz Composite = 3.9 grms

3.15.4.5 Post-Vibration Functional Test - Remove EGSW from vibration fixture, install in Force Test Fixture and perform functional test in accordance with Appendix I paragraph 3.3.1 and 3.3.2.

4. QUALITY ASSURANCE PROVISIONS

4.1 EGSW failures. - A failure shall be defined as any occurrence which results in the inability of the test specimen to perform its required functions within specified limits under the conditions and for the duration specified. In event of a failure, the following action shall be taken:

(a) The test shall be suspended and the cause of the failure determined.

(b) If the failure is due to a component part, the part shall be replaced with an approved replacement.

(c) If the failure is due to marginal adjustment, the equipment shall be realigned as required.

(d) When the cause of the failure is corrected, the test shall be resumed, repeating the portion of the test in progress when the failure occurred, or proceeding as specified by an authorized quality assurance inspection representative. When the repair significantly influences previous test data, those tests shall be repeated.

4.2 Tolerances. - All tolerances shall be as specified in paragraph 3.9.

4.3 Qualification test report. - Upon completion of the qualification tests, a qualification test report shall be prepared. As a minimum the report shall contain the following:

(a) A running time log

(b) All pertinent test data

(c) A list of major test equipment used

(d) Calibration charts for the test systems used

(e) Referenced list of test procedures

(f) Irregularities (if applicable)

(g) Summary of inspection information

(h) Trouble and failure reports (if applicable)

(i) Evaluation of test data

(j) Comparison of results with objectives and design performance requirements.

(k) Conclusions

5. NOTES

5.1 Changes, deviations, or waivers. - Requests for changes, deviations, or waivers to the requirements of this document shall be submitted in writing to the Manufacturing Engineering Laboratory, Science and Engineering (S&E-ME-MX), George C. Marshall Space Flight Center (MSFC), Huntsville, Alabama, for approval.

APPENDIX I

ACCEPTANCE TEST PROCEDURE FOR GRAVITY SUBSTITUTE WORKBENCH (ELECTROSTATIC)

Approved: P. S. Theobald 7/22/70
Project Supervisor

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LIST OF ILLUSTRATIONS

DATA SHEETS

1.0 REFERENCE DOCUMENTS

The following documents shall be necessary when acceptance tests are performed on the supply.

Electrical Schematic	95M12026
Electronic Assembly	95M12019
Electrostatic Workbench Assembly	95M12015

2. INSPECTION INSTRUMENTS

2.1 Insulation Resistance Tester

MAKE: General Radio
MODEL: 1862-C

2.2 Electrostatic Voltmeter

MAKE: Singer
MODEL: ESH

2.3 Volt-OHM-Milliammeter

MAKE: Simpson
MODEL: 260

2.4 Load Resistors

QUANTITY	MAKE	MODEL	RESISTANCE
2	IRC	MVQ	3300 Megohms
2	IRC	MVT	1 Megohm

A

2.5 Power Supply

MAKE: KEPCO
MODEL: SM-36-5M

2.6 Differential Voltmeter

MAKE: FLUKE
MODEL: 825

3.0 TEST PROCEDURE

This test procedure covers operations and tests which are to be performed during the acceptance testing. The operations are described in chronological order, along with the requirements for acceptance. All tests are at room temperature.

3.1 Non Functional Operations

3.1.1 Identification - The switches and cable connectors shall be temporarily identified with their reference designations as shown in Figure 1 and the test assembly marked with the MSFC part number and serial number.

3.1.2 Visual Inspection - A visual inspection shall be performed to inspect for such items as physical characteristics, workmanship, finish requirements and conditions of protective coatings.

3.1.3 Verification of Manufacturing Processes - The following listed items and subassemblies require critical manufacturing in-process inspections that cannot be verified during the acceptance inspections. The inspection cards for each item should be checked at this time to assure a CCSD Quality Control Stamp and a Government Inspection Stamp.

a) High voltage capacitors, C13 through C40
b) High voltage diodes, CR8 through CR35
c) Transformers T1, T2, T3, and T4
d) High voltage cable
e) High Voltabe Module
f) Low Voltage Section Assembly

3.2 Functional Tests - Electronic Assembly. This assembly shall be bench tested. Clip leads may be used for connection to terminal E1 and to the shank (NOT tip) of the ion source. Mating connectors must be used with J1 and P2.

3.2.1 Electrical Isolation - Using an insulation resistance tester, with a test voltage of 100 vdc, measure the insulation resistance between the following points with switch S1 on.

Positive test point	Negative test point
a) Pin P2/A	Terminal E1
b) Pin P2/A	Case
c) Pin J1/A	Case
d) High voltage lead	Case
e) High voltage lead	Terminal E1

Discharge all inputs and outputs to their respective returns.

P2/C to P2/A
J1/A to E1
High voltage lead to E1

Repeat the above with reversed polarity of test voltage **except for E1 to HV lead.** D

Turn switch S1 off.

Requirement: All measurements shall be 50 megohms minimum.

3.2.2 Continuity Test - Connect the positive polarity lead of an ohmmeter to pin P2/A and the negative polarity lead to pin P2/C of the Electronic Assembly (power supply) under test. The reading shall be more than 100K ohms. Reverse the connections, the reading shall be more than 8.65K ohms.

3.2.3 Starting Test - Connect the test power supply as shown in Figure 2 (R_1 = 3300 megohms and R_2 = 3300 megohms). Adjust the supply voltage (V_s) to 24 $\pm$ .5 vdc. Position switch S2 to position 1. Turn switch S1 on. Determine that the test power supply is operating by noting presence of the following. A B

a) Input current (I_s)
b) Output Voltages (V_m and V_{Lo})
c) Illumination of pilot lamp DS-1

Monitor the above with switch S2 in positions 2, 3, and 4. Leave switch S2 in position 4 and start the supply 25 times by turning switch S1 on, then off.

Requirement: The supply shall start each time as indicated by a, b, and c above.

3.2.4 Output Regulation Test

3.2.4.1 Output regulation test at nominal supply voltage - Connect the circuit as shown in Figure 2. Adjust the supply voltage (V_s) to 28.0 $\pm$ .5 volts. Select standard loading of R_1 = 3300 megohms, R_2 = 3300 megohms. Turn switch S2 to position 4. Turn switch S1 to ON. Record the electrostatic voltmeter reading (V_m) at the High Voltage output. Record the low voltage output voltmeter reading (V_{Lo}). Record the supply current milliammeter reading (I_s). Calculate the values of voltage (V_{Ho}) and current I_{Ho} for the high voltage output. $V_{Ho} = \frac{R_1 + R_2}{R_1} \times V_m$;

$I_o = V_{Ho}/R_1 + R_2)$. Also record and calculate values of the above parameters when the switch S2 is turned successively to positions 3, 2, and 1. Turn switch S1 to OFF. Change the load resistors R_1 = 0.5 megohms, R_2 = 0 making a complete record of the aforementioned parameters.

Requirement: For standard load, V_{Ho}, and V_{Lo} shall be within limits of Table 1. I_{Ho} shall not exceed 1.0 mA.

3.2.4.2 Current limiting capability test - Connect a hazard simulation load (R_1 = 0.5 megohms and R2 = 0). Adjust supply voltage (V_s) to 24 $\pm$ .5 volts. Turn S2 to position 4. Turn switch S1 to ON. Record, and calculate data for the parameters V_{Ho}, I_{Ho}, I_s, and V_{Lo}. Repeat the test for all other positions of S2.

Repeat the foregoing test at supply voltage V_s = 34 volts.

Requirement: I_{Ho} shall not exceed 1.0 milliamperes for any load or switch position.

TABLE 1

Switch S2 Position	Output V_{Ho} (KV)	Voltages V_{Lo} (V)
4	40 ± 8	300 ± 60
3	30 ± 6	300 ± 60
2	20 ± 4	300 ± 60
1	10 ± 2	300 ± 60

3.2.5 Short Circuit Test of Low Voltage Output - Connect pin J1/A to terminal E1. Set high voltage load resistors to R_1 = 3300 megs and R_2 = 3300 megs. Adjust supply input voltage to 28 v ± .5. Set switch S2 to position 4. Turn on switch S1. Allow the power supply to operate for five (5) minuts. Turn off switch S1. Remove shorting lead from pin J1/A to terminal E1. Turn on switch S1, record V_{Lo} and calculate V_{Ho}.

Requirement: The supply shall show no evidence of damage and value of the outputs V_{Lo} and V_{Ho} shall be within 5% of those measured in 3.2.4.

3.2.6 Warm-up Voltage Drift - Connect circuit as shown in Figure 2. Adjust supply voltage (V_s) to 28 ± .5 vdc. Use the normal values of load resistors R1 = 3300 megohms and R2 = 3300 megohms. Turn switch S1 on. Record readings of electrostatic voltmeter (V_M) and low voltage output voltage (V_{Lo}) for each of the positions 1, 2, 3, and 4 of switch S2 within the first two minutes of operation. After one (1) hour of operation, record the new readings for the same parameters. Turn switch S1 to OFF. Calculate V_{Ho}. $V_{Ho} = 2 \times V_M$.

Requirement: The output voltage change of (V_{Ho}) shall be less than 5 percent of the initial value. The output voltage change (V_{Lo}) shall be less than ± 10 volts.

3.2.7 Input/Output Voltage Test - Connect the circuit as shown in Figure 2. Use the normal values of load resistors R1 = 3300 megohms and R2 = 3300 megohms. **Turn switch S1 to ON. Then lower supply voltage Vs to 22±.5 vdc** and record the values of V_s, V_{Lo}, and V_M for each of the positions 1, 2, 3, and 4 of switch S2. Repeat the above with the supply voltage adjusted to 24, 26, 28, 30, 32, and 34 volts ± .5 v. Reset voltage 28 v and record results. Turn switch S1 to OFF. Calculate V_{Ho} for each condition. $V_{Ho} = 2 \times V_M$.

Requirement: The power supply shall not be damaged when exposed to undervoltage of 22 to 24 volts or overvoltage of 32 to 34 volts and shall perform satisfactorily upon return to normal voltage.

3.3 Functional Tests - Electrostatic Workbench - The following tests will be conducted after all subassemblies of the Electrostatic Workbench have been installed in the Force Test Fixture as shown in Figure 3.

3.3.1 Electrostatic Voltage Test - Connect circuit as shown in Figure 4. Adjust supply voltage (V_s) to 28 volts $\pm$ .5. Turn switch S2 to position 1. Locate electrostatic voltmeter probe in approximate center of the ion shield cover (between holes) and in contact with it. Turn on switch S1 and allow approximately one minute before reading and recording the electrostatic field voltage (V_f). Repeat with switch S2 in positions 2, 3, and 4, each time allowing approximately one minute between S2 position change and V_f reading. Turn switch S1 to OFF. C

Requirement:

Switch S2 Position	Electrostatic Field Voltage (Min.)	
1	1.3 KV	C
2	6.0 KV	C
3	15.0 KV	
4	20.0 KV	

3.3.2 Electroadhesive Force Measurement - Connect circuit as shown in Figure 5. Adjust supply voltage to 28 volts $\pm$ .5 v. Position switch S2 to position 4. Turn on switch S1. After approximately one minute, zero out force measuring geometry with test disc in contact with table surface. Note distance reading "d_o" for this condition. Record readings of table current (I_T), leakage current (I_B), and power supply current (I_{ES}). Energize motor switch and note distance reading at breakaway of test disc (d_B). Turn motor switch off and reset apparatus to zero. At intervals of approximately 5 minutes, repeat this test 4 times. Duplicate the above procedure for each of the switch S2 positions 3, 2, and 1, allowing approximately 5 minutes after switching before taking readings. Rotate the table approximately 180^o and repeat all of the above procedure. Calculate the net support point travel (D), convert to force, and calculate average for each switch S2 position. Finally calculate average of the two table locations for each switch S2 position.

Requirement: The average force measurement for each of the S2 positions shall not be less than

S2 position	Average Force-grams
4	11.0
3	8.0
2	3.0
1	No requirement

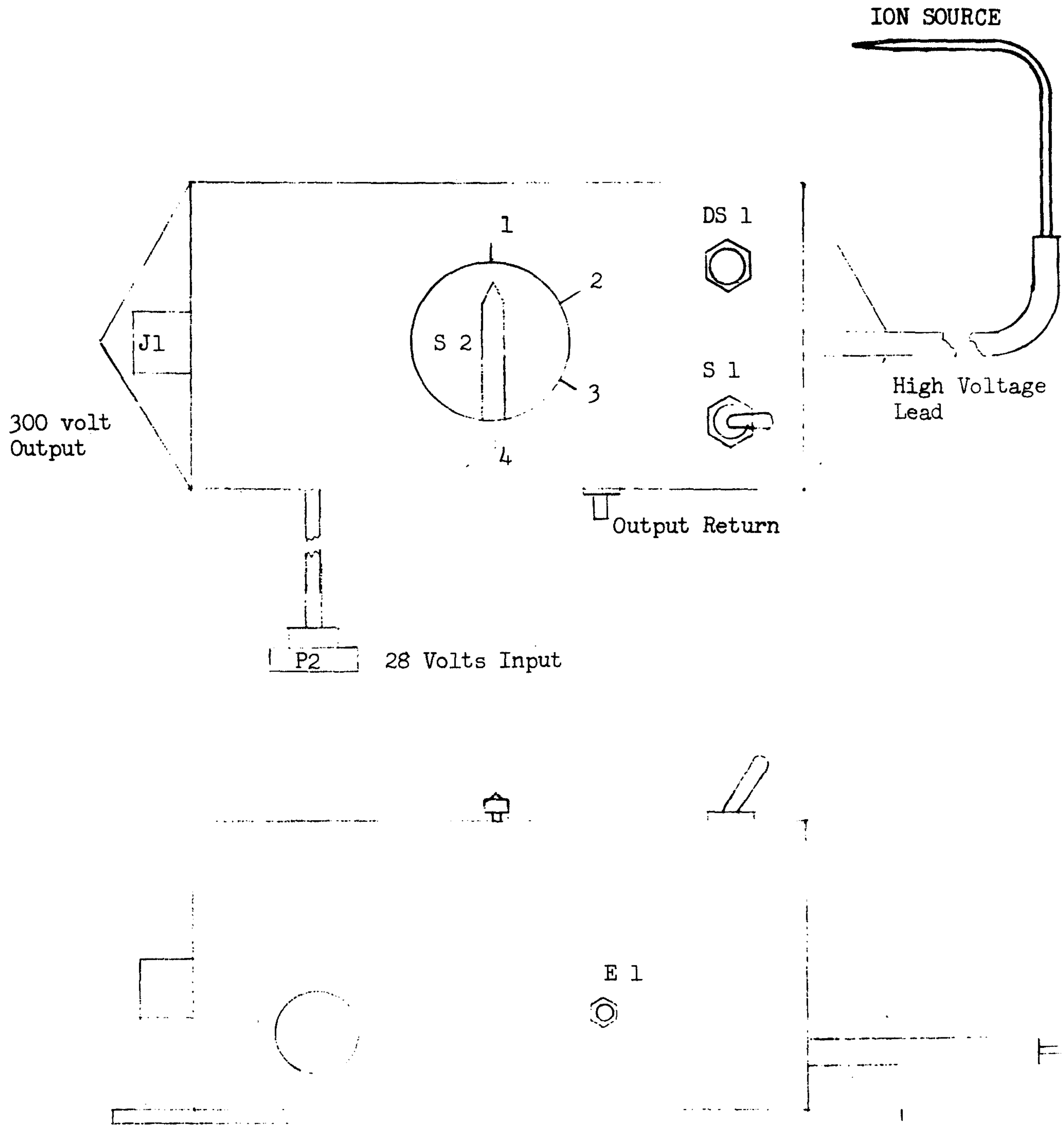

ION SOURCE
DS 1
1
2
S 2
J1
3
S 1
High Voltage
Lead
300 volt
Output
4
Output Return
P2
28 Volts Input
E 1

FIGURE 1

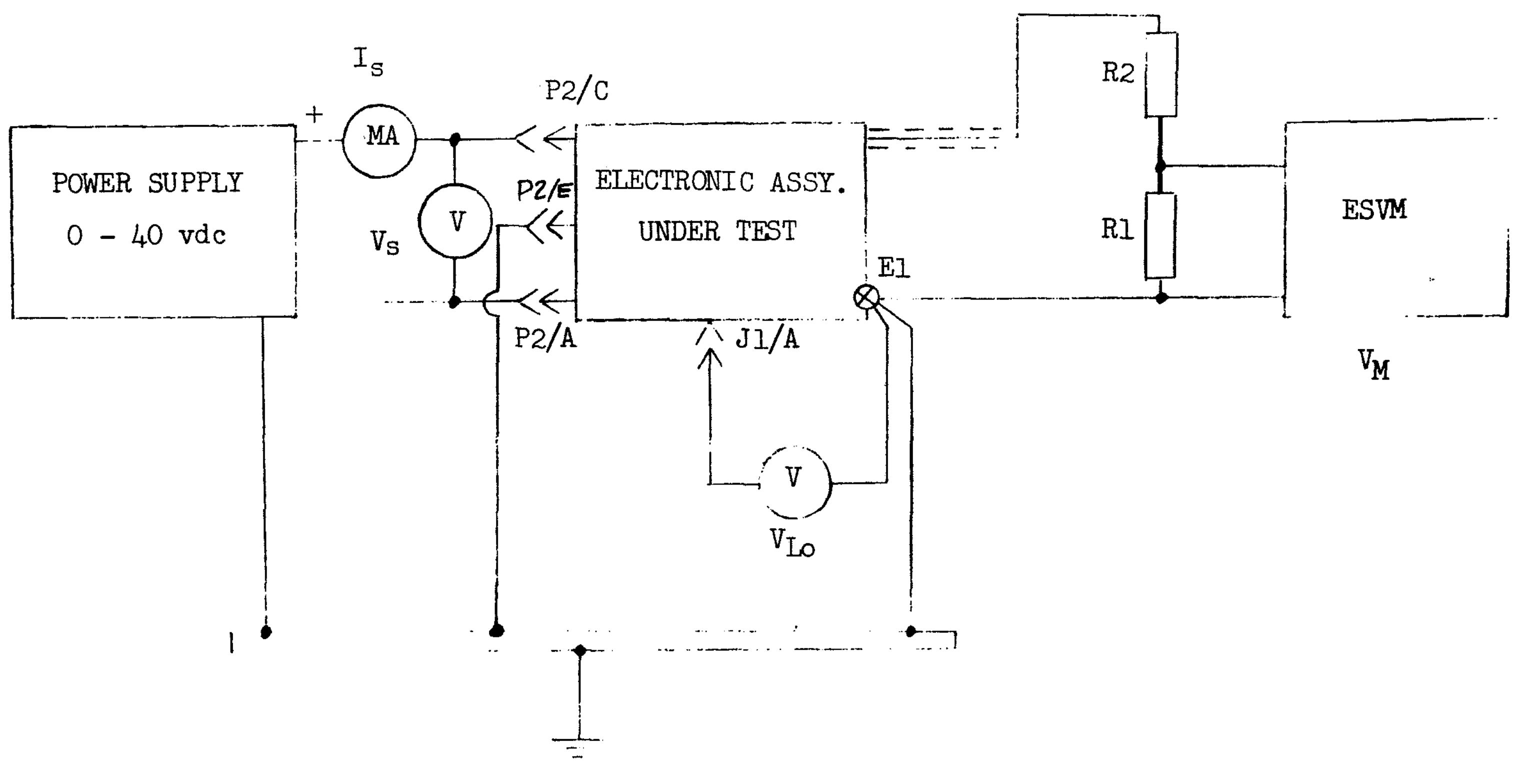

POWER SUPPLY
0 - 40 vdc
+
I_s
MA
V
V_s
P2/C
P2/E
P2/A
ELECTRONIC ASSY.
UNDER TEST
E1
J1/A
V
V_{Lo}
R2
R1
ESVM
V_M

FIGURE 2.

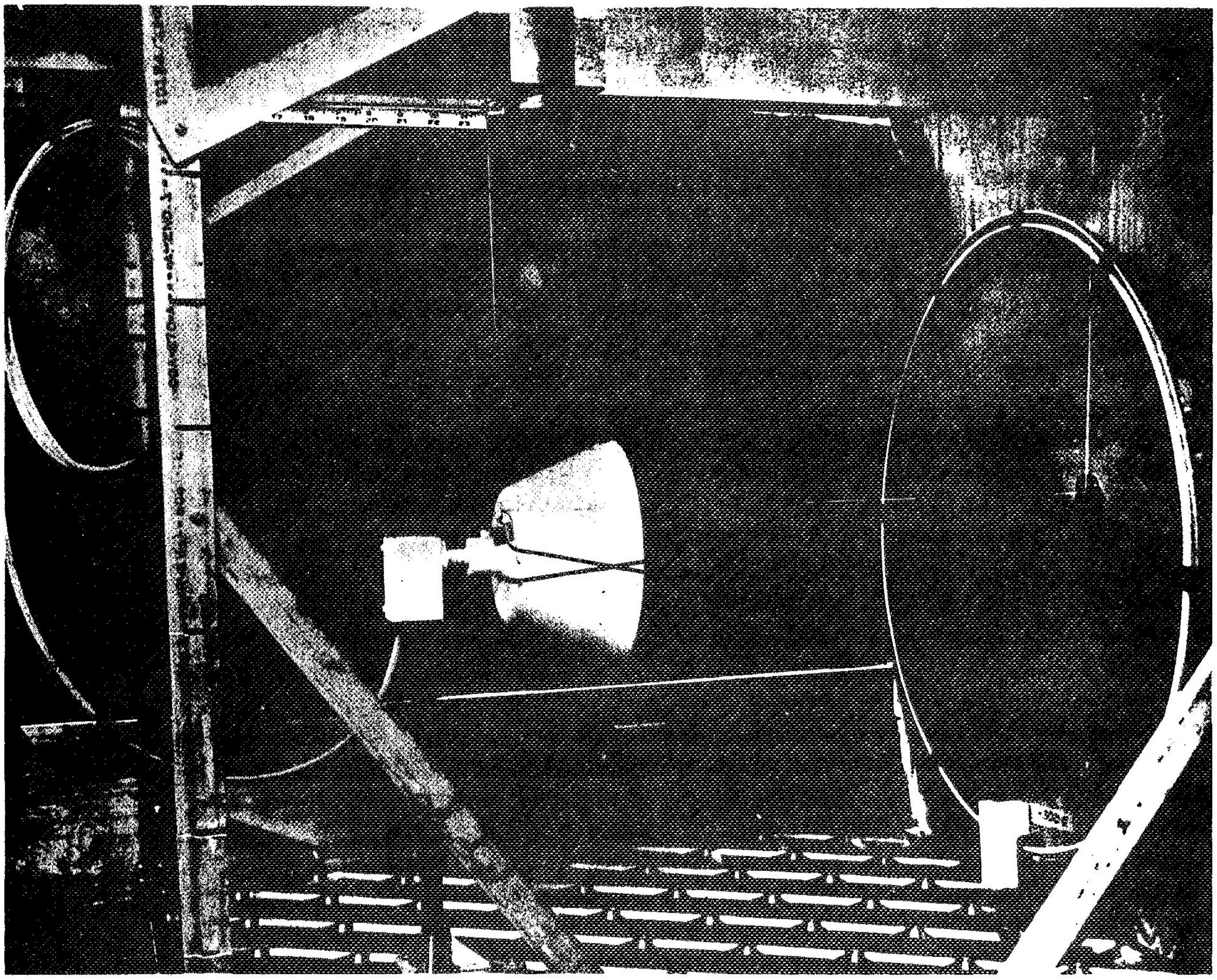
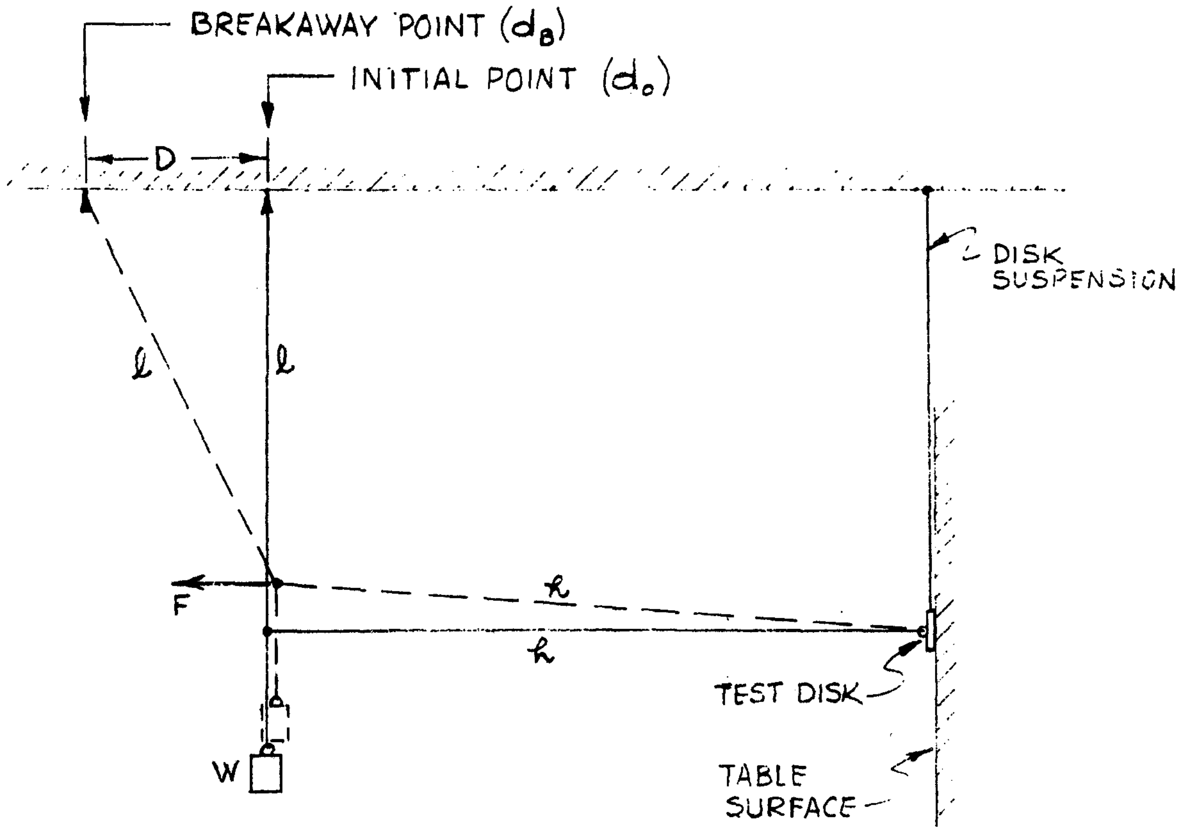


FIGURE 3. FORCE TEST FIXTURE



APPROX. FORMULA: $F = \dfrac{WDh}{\sqrt{\ell^2 - D^2}\,(D+h) - D\ell}$ $\qquad D = d_B - d_o$

Figure 3. FORCE TEST FIXTURE - SCHEMATIC

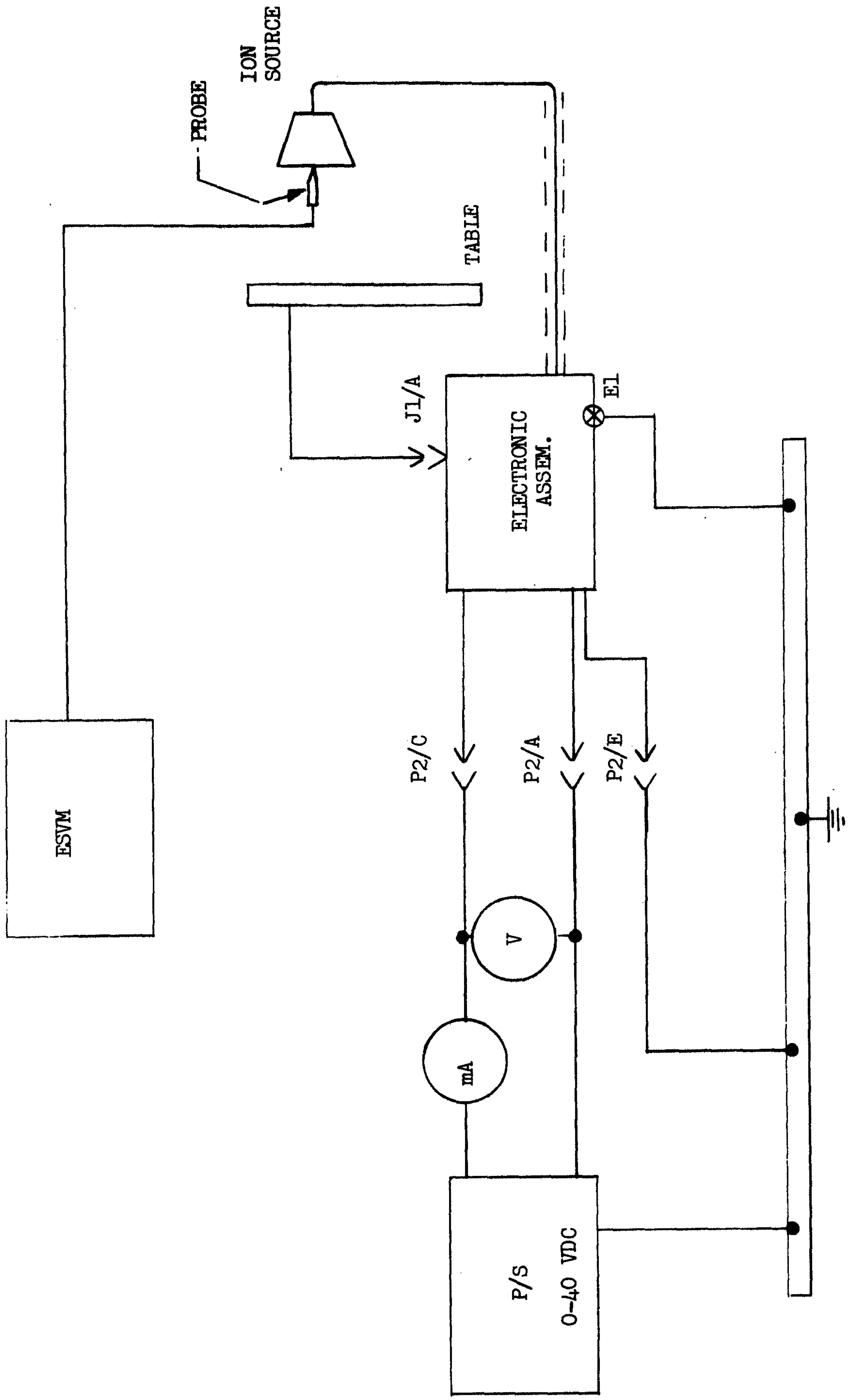
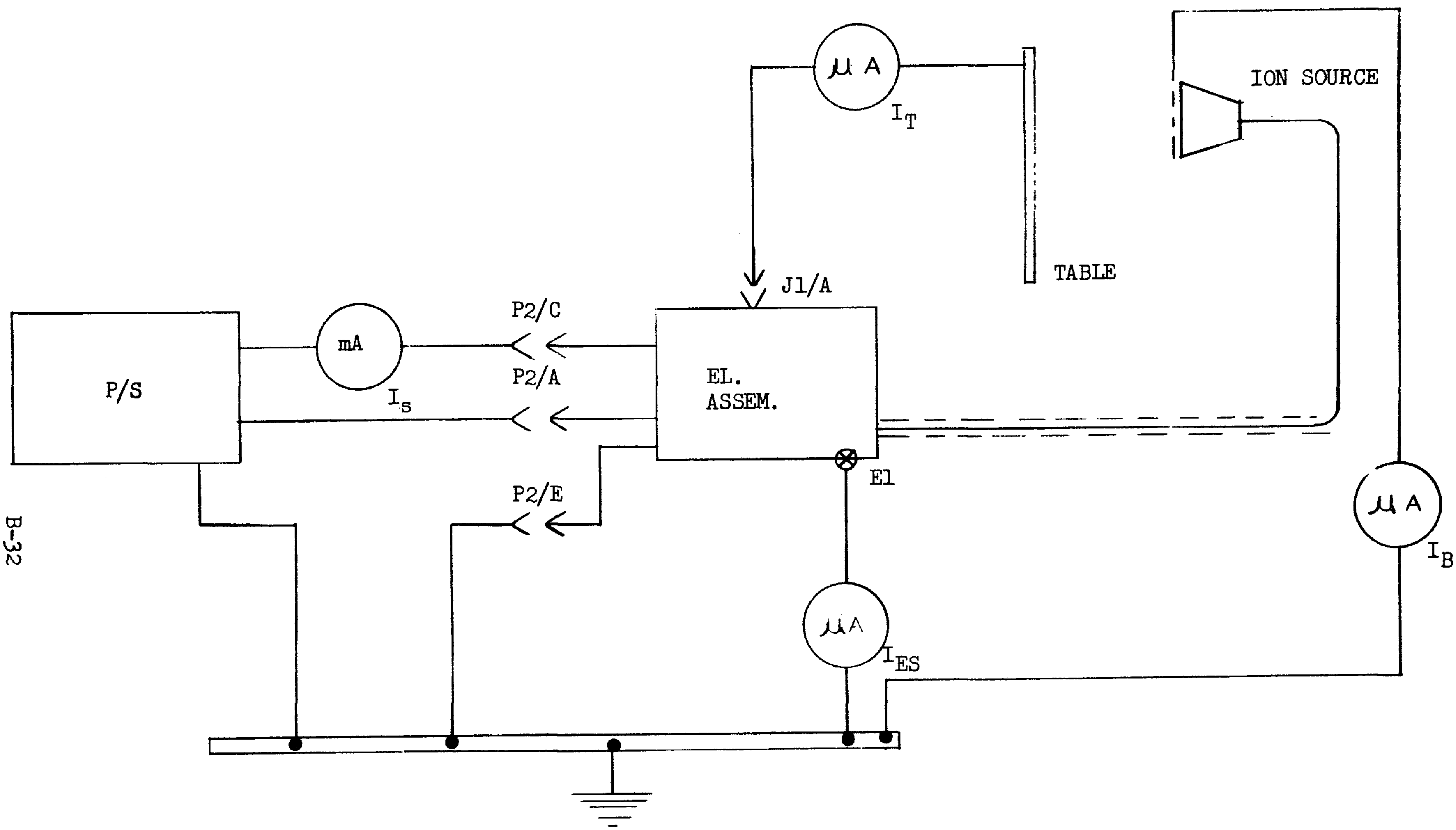

ION SOURCE
PROBE
TABLE
J1/A
E1
ELECTRONIC ASSEM.
ESVM
P2/C
P2/A
P2/E
V
mA
P/S
0-40 VDC

FIGURE 4.



μA
I_T
TABLE
ION SOURCE
J1/A
P/S
mA
I_s
P2/C
P2/A
EL.
ASSEM.
E1
P2/E
μA
I_{ES}
μA
I_B

FIGURE 5.

DATA SHEET NO.______

ELECTRICAL ISOLATION TEST

DATE OF TEST_______

REF. PARA. 3.2.1

TEST BY__________

UNIT____________

POSITIVE TEST POINT	NEGATIVE TEST POINT	READING (MEGOHMS)	REQUIREMENT (MEGOHMS)
P2/A	E1		50 MINIMUM
P2 A	CASE		
J1 A	CASE		
HIGH VOLT LEAD	CASE		
HIGH VOLT LEAD	E1		
E1	P2 A		
CASE	P2 A		
CASE	J1 A		
CASE	HIGH VOLT LEAD		
~~E1~~	~~HIGH VOLT LEAD~~		~~50 MINIMUM~~

D

INSTRUMENTS:

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO
INSULATION RES TESTER				

CONTINUITY TEST

REF. PARA. 3.2.2

DATA SHEET NO.______

DATE OF TEST ______

TEST BY ____________

UNIT______________

POSITIVE TEST POINT	NEGATIVE TEST POINT	READING (OHMS)	REQUIREMENT (OHMS)
P2/A	P2/C		
P2/C	P2/A		

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO
OHMMETER				

DATA SHEET NO.______

STARTING TEST

DATE OF TEST________

REF. PARA. 3.2.3

TEST BY_____________

UNIT________________

POSITION SWITCH S-2	I_s (mA)	OUTPUT VOLTAGE LOW V_{Lo} (V)	OUTPUT VOLTAGE HIGH V_M (KV)	$V_{Ho} = V_M \times \frac{R_1 + R_2}{R1}$ (KV)	PILOT LAMP (DS-1)
1					
2					
3					
4					

SUPPLY STARTED

5 10 15 20 25 TIMES

INSTRUMENTS

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO
MILLIAMMETER I_s				
VOLTMETER V_s				
VOLTMETER V_{Lo}				
VOLTMETER V_M				

DATA SHEET NO.__________

DATE OF TEST __________

TEST BY__________

UNIT __________

OUTPUT REGULATION

REF. PARA. 3.2.4 (S2 positions 4, 3, 2 & 1)

					S2 Position 4					S2 Position 3				
V_s	R1	R2	R1 + R2	$\frac{R_1+R_2}{R_1}$	V_M (KV)	V_{Ho} (KV)	I_{Ho} (MA)	I_s (mA)	V_{Lo} (V)	V_M (KV)	V_{Ho} (KV)	I_{Ho} (MA)	I_s (mA)	V_{Lo} (V)
28	3300	3300	6600	2										
28	.5	0	0.5	1										
24	0.5	0	0.5	1										
34	0.5	0	0.5	1										
					S2 Position 2					S2 Position 1				
28	3300	3300	6600	2										
28	0.5	0	0.5	1										
24	0.5	0	0.5	1										
34	0.5	0	0.5	1										

(A)

DATA SHEET NO.________

OUTPUT REGULATION

DATE OF TEST ________

REF. PARA. 3.2.4 (S2 positions 2 & 1)

TEST BY______________

UNIT ______________

BLANK PAGE

(A)

DATA SHEET NO.________

DATE OF TEST__________

TEST BY______________

UNIT_________________

LOW VOLTAGE SHORT CIRCUIT

REF. PARA. 3.2.5

SWITCH POSITION S2	INITIAL REF. 3.2.4			V_m	V_{Ho}	INITIAL REF. 3.2.4			V_{Lo}
	V_{Ho}	+5%	-5%			V_{Lo}	+5%	-5%	
1									
2									
3									
4									

INSTRUMENTS

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.
VOLTMETER V_m				
VOLTMETER V_{Lo}				

DATA SHEET NO.______

DATE OF TEST________

TEST BY____________

UNIT_____________

WARM UP VOLTAGE DRIFT

REF. PARA. 3.2.6

S2 SWITCH SETTING	INITIAL (t =)			FINAL (t =)			DRIFT	
	V_M (KV)	V_{Ho} (KV)	V_{Lo} (V)	V_M (KV)	V_{Ho} (KV)	V_{Lo} (V)	V_{Ho} (KV)	V_{Lo} (V)
1								
2								
3								
4								

DATA SHEET NO.________

INPUT VS OUTPUT TEST

DATE OF TEST________

REF. PARA. 3.2.7

TEST BY________

UNIT________

INPUT V_s (V)	SWITCH S2 POSITION	LOW V_{Lo} (V)	OUTPUT VOLTAGE HIGH V_M (KV)	$V_{Ho} = V_M\left(\frac{R1 + R2}{R1}\right)$ (KV)
22	1			
	2			
	3			
	4			
24	1			
	2			
	3			
	4			
26	1			
	2			
	3			
	4			
28	1			
	2			
	3			
	4			
30	1			
	2			
	3			
	4			
32	1			
	2			
	3			
	4			
34	1			
	2			
	3			
	4			
28	1			
	2			
	3			
	4			

DATA SHEET NO.______

DATE OF TEST______

TEST BY______

UNIT______

ELECTROSTATIC VOLTAGE TEST

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1		
2		
3		
4		

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.

DATA SHEET NO.______

DATE OF TEST______

TEST BY______

UNIT______

ELECTROADHESIVE FORCE MEASUREMENT

Ref. Para. 3.3.2

INITIAL TABLE ORIENTATION d_o = ______ ; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1							
	2							
	3							
	4							
3	1							
	2							
	3							
	4							
2	1							
	2							
	3							
	4							
1	1							
	2							
	3							
	4							

ORIENT TABLE 180° d_o = ______

4	1							
	2							
	3							
	4							
3	1							
	2							
	3							
	4							

DATA SHEET NO.______

DATE OF TEST________

TEST BY____________

UNIT_______________

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED)

Ref. Para. 3.3.2

ORIENT TABLE 180°

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1							
	2							
	3							
	4							
1	1							
	2							
	3							
	4							

APPENDIX II

ELECTROMAGNETIC INTERFERENCE TEST PLAN
FOR THE GRAVITY SUBSTITUTE WORKBENCH (ELECTROSTATIC)

Approved: P. E. Theobald 7/22/70
Project Supervisor

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LIST OF ILLUSTRATIONS

1 INTRODUCTION

1.1 Scope

This Electromagnetic Interference (EMI) Test Plan describes the tests, specified by MIL-I-6181D (reference 1), to be performed on the Gravity Substitute Workbench (Electrostatic). Details of the test configuration and procedures will be included in the final test report.

2 TEST EQUIPMENT

The test equipment, or equivalent, listed in table 1, will be used to perform the required tests.

Table 1. Test Equipment

Nomenclature	Manufacturer	Model No.	Serial No.
Noise and Field Intensity Meter	Empire	NF-105	2314
Line Impedance Stabilization Network	Filtron	FSR701D	None
Milliammeter	Sensitive Research	University	945827
Isolation Transformer	Solar Electronics	6220-1	None
Switch DPDT			
Power Supply (0 to 40 V)	Harrison	802B	1952
Electrostatic Voltmeter	Singer	ESH	945931
Milliohmeter	Shallcross	670-A	32779

3 TEST EQUIPMENT ADJUSTMENT

3.1 Interference Measuring Equipment

3.1.1 NF-105 Noise and Field Intensity Meter

The NF-105 Noise and Field Intensity Meter shall be adjusted using the internal impulse generator. The visual substitution method shall be used in determining the magnitude of the generated noise with the function switch in PEAK DETECTOR position.

4. TEST CONDITIONS

4.1 Temperature

The EMI tests shall be performed at a controlled temperature of 70 (+5)°F.

4.2 Mounting

The Workbench Assembly will be securely mounted in its normal spatial relationship and effectively bonded to the copper ground plane in the Engineering Laboratory Screen Room.

4.3 Configuration

The Workbench Assembly will be in accordance with manufacturing drawing 95M12015.

4.4 Test Sample Parameters

The input current and the high voltage output (as evidenced by the Appendix I para. 3.3.1 Electrostatic Voltage Test) will be recorded just prior to any EMI testing. The measurement will be made on the #2 and #4 selector switch settings.

4.5 Isolation

All signal inputs to the measuring equipment shall be isolated from the ac power ground.

4.6 Input Power

The Workbench Assembly shall have an input voltage of 28.0 VDC ±2% during all EMI tests.

4.7 High Voltage Output Ranges

All EMI tests will be performed on the 20 KV range, then repeated on the 40 KV range.

5 ANTICIPATED INTERFERENCE

5.1 Conducted Broadband Interference

Conducted broadband interference originating in the high voltage power supply of the Workbench Assembly is anticipated on the input power leads over the frequency range from 0.15 to 25 MHZ.

5.2 Radiated Broadband Interference

Radiated broadband interference emanating from the test sample is anticipated over the frequency range from 115 to 400 MHZ.

5.3 Continuous Wave (CW) Interference

No CW interference is anticipated.

6 EMI TESTS

6.1 Conducted Interference (Broadband Measurements)

The conducted interference test will be performed on the Workbench Assembly Electronic Assembly input leads as specified in paragraph 6.1.1. Measurements will be made with the NF-105 across the frequency spectrum from 0.15 to 25 MHZ.

6.1.1 Line Impedance Stabilization Network Measurements (figure 1)

The line impedance stabilization networks (LSN) will be inserted in each leg ((-) and (+) 28 VDC) of the power input to the Electronic Assembly. The NF-105 is connected through a double-shielded coaxial cable to the plus 28 VDC LSN. Measurements are repeated with the NF-105 connected to the 28 V common LSN.

6.2 Radiated Interference Measurements (Broadband) (figure 2)

The radiated interference test shall be conducted on the Workbench Assembly over the frequency range between 0.15 to 400 MHZ. The NF-105 will be used with three plug-in tuning units to cover the test frequency spectrum. The radiated interference test configuration is shown in figure 2. The test configuration for the frequency spectrum between 0.15 and 30 MHz is shown in figure 3, and the test configuration for the frequency spectrum between 30 and 400 MHz is shown in figure 4. Paragraph 6.3 categorizes the frequency range and the type of antenna required. The antenna system is connected in accordance with figures 3 or 4, as applicable, opposite the center of the Workbench Assembly. In figures 3 and 4, the electrical bond between the NF-105 and the ground plane is omitted until the following steps are completed:

a. The full frequency range of the lowest tuning band is scanned for the frequency of the maximum interference.

b. The antenna is moved in a horizontal position until a maximum reading is obtained, except that a dipole antenna with dimensions longer than the test sample shall be placed opposite the center of the sample.

c. The NF-105 is then bonded, electrically, through a copper ground strap to the ground plane.

6.3 Radiated Interference Test Antennas Required

Frequency	Antennas
0.15 - 25 MHz	41-Inch Rod
25 - 35 MHz	35 MHz Dipole
35 - 1000 MHz	Tunable Dipole

6.4 D. C. Bonding Measurement

A D. C. Bonding measurement will be made between the case of the Electronic Assembly and the mounting structure of the Workbench

Assembly in accordance with MIL-B-5087B.

7 PERFORMING PERSONNEL AND TEST LOCATION

The complete EMI test on the Workbench Assembly, in accordance with MIL-I-6181D, will be performed by Chrysler Corporation Space Division (CCSD) qualified personnel in the shielded enclosure located in the EMI Laboratory at Michoud. Tests will be performed under controlled conditions, with minimum personnel activity therein during test.

The shielded enclosure is a double-shielded electromagnetic enclosure which was certified by the Shielding Division of Shieldtron, Inc. on November 18, 1963. Certification was witnessed by CCSD EMI personnel and a NASA Quality Control representative.

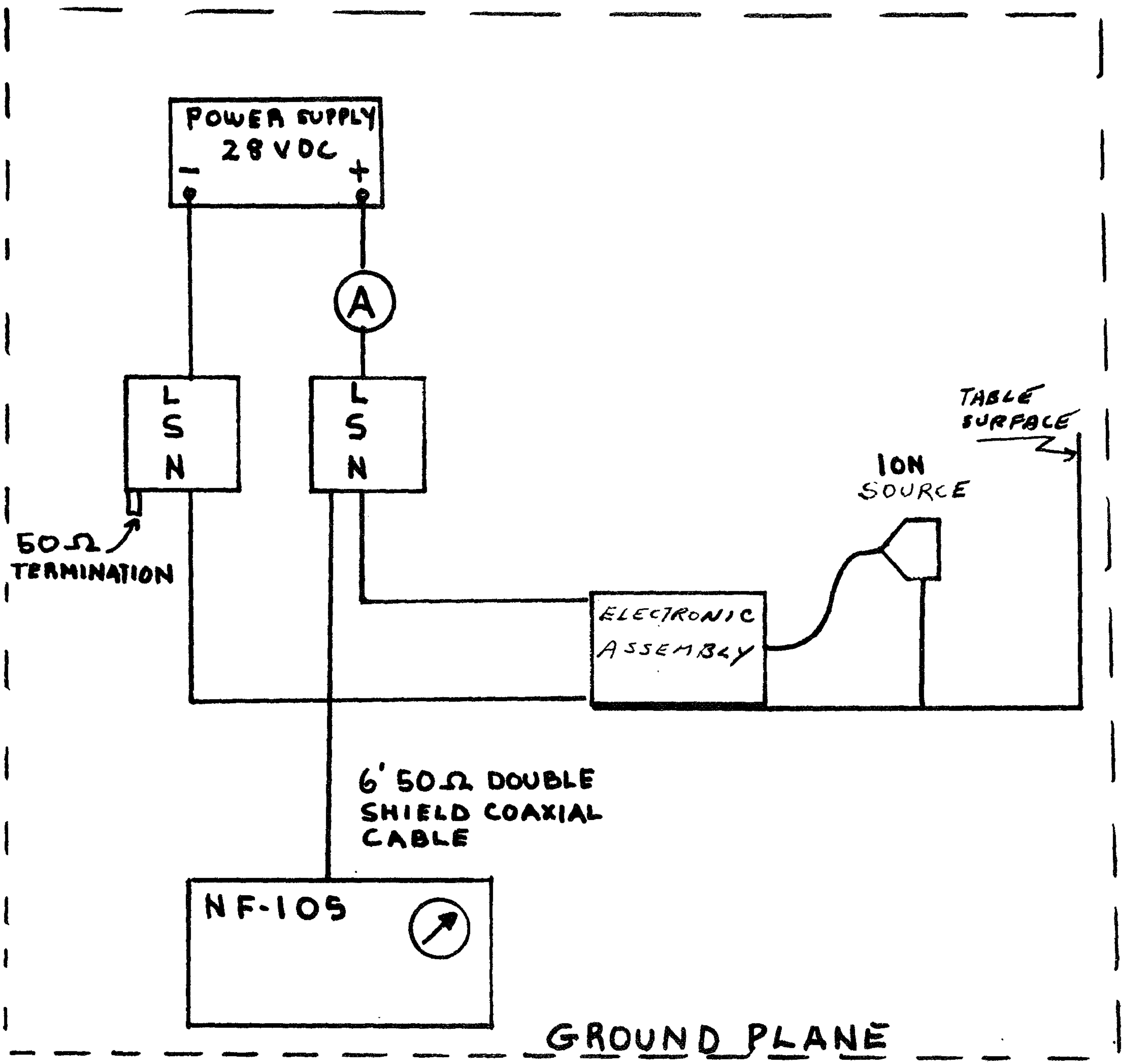

Figure 1. Conducted Interference (LSN) Measurements Test Configuration (Frequency Spectrum 0.15 to 25 MHz)

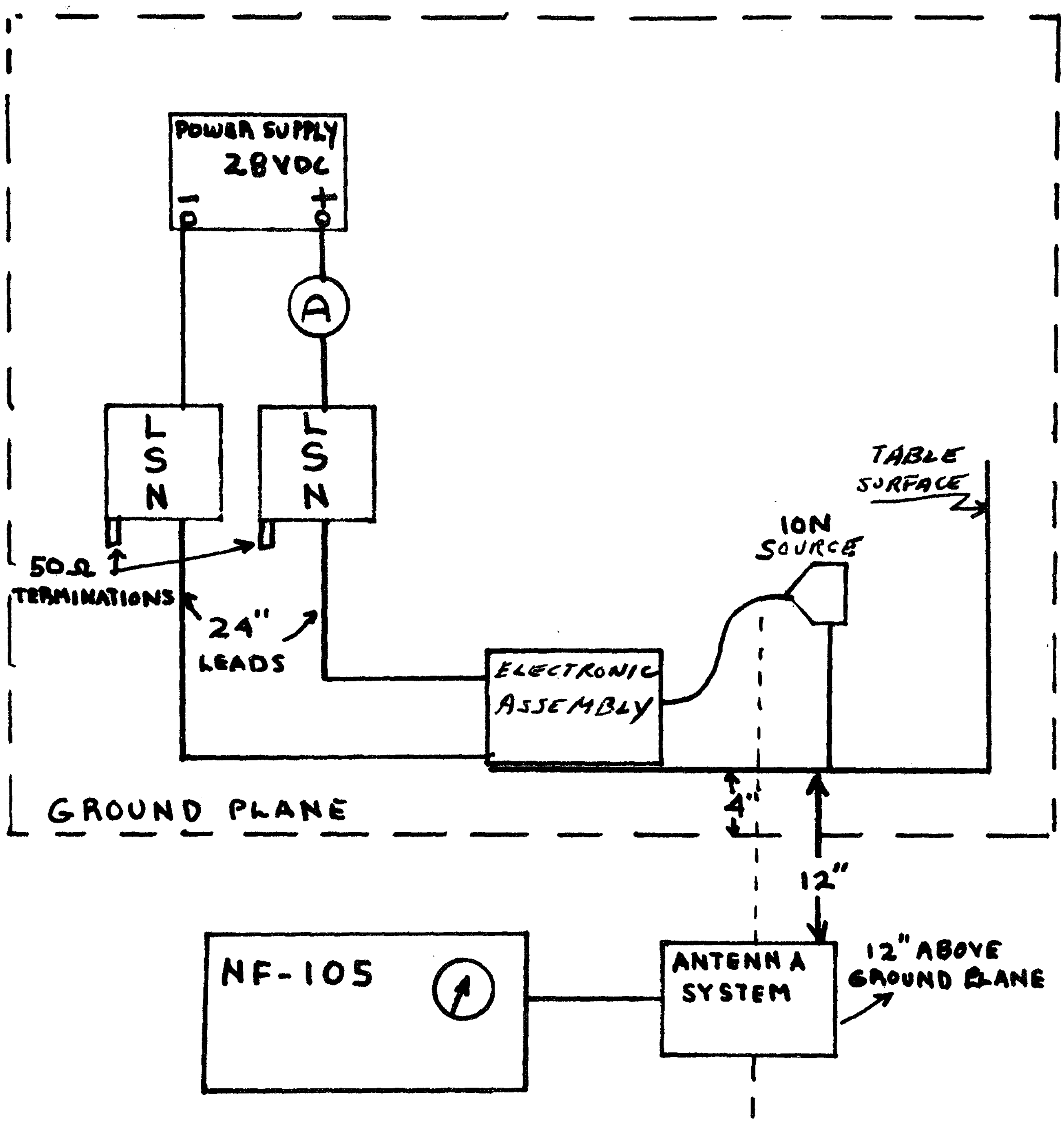

Figure 2. Radiated Interference Measurements, Test Configuration, (Frequency Spectrum 0.15 to 400 MHz)

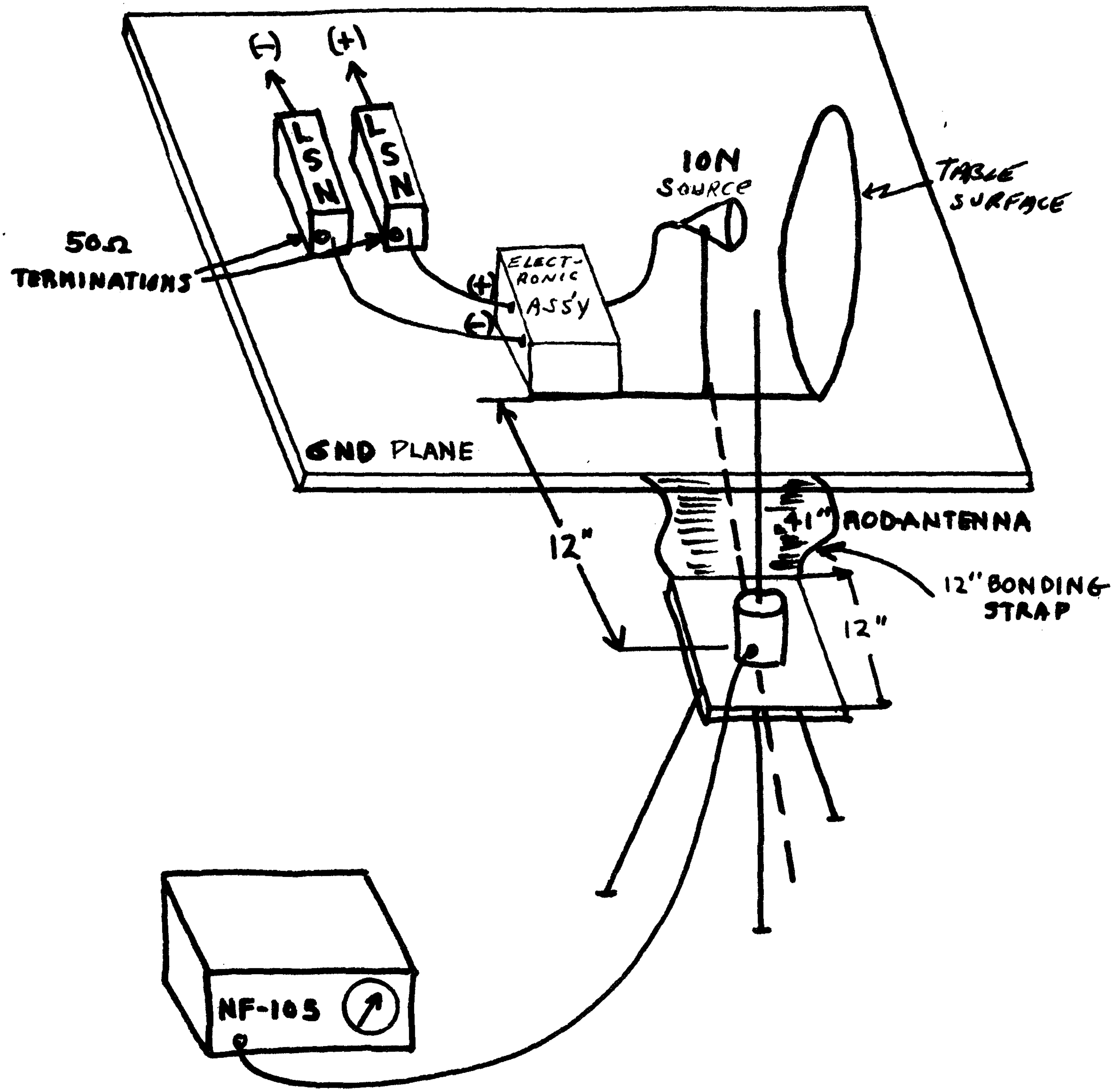

Figure 3. Antenna Configurations for the Frequency Range 0.15 to 30 MHz

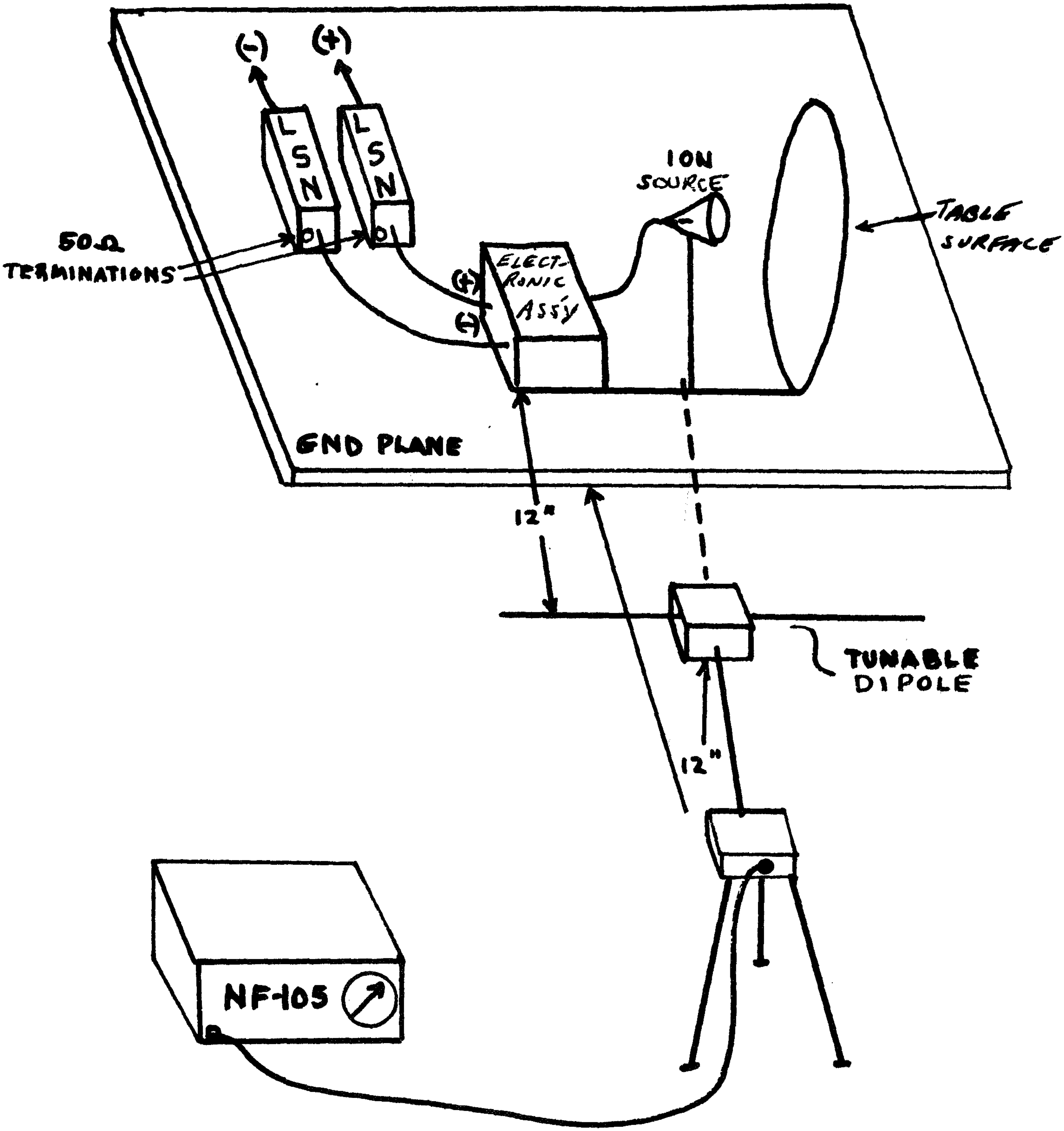

Figure 4. Antenna Configuration for Frequency Range 30 to 400 MHz

APPENDIX A - REFERENCES

1. MIL-I-6181D, Interference Control Requirements

2. MIL-B-5087B, Electrical Bonding

3. CCA 903, Bonding of Electrical Components

4. Shielding Division of Shieldtron, Inc., Test Report No. 113-63, dated November 18, 1963.

APPENDIX C

QUALITY CONTROL INSTRUCTIONS

FOR AN

ELECTROSTATIC GRAVITY SUBSTITUTE WORKBENCH

(QUALIFICATION TEST)

642-61209 -A REV. JULY 63

QCI NO.	REV.	DIST. CODE	SPACE DIVISION CHRYSLER CORPORATION	PART NO.	SHEET 1 OF 6
95M12015 A	B		QUALITY CONTROL INSTRUCTIONS	PART NAME: QUALIFICATION TESTS - ELECTROSTATIC WORKBENCH	
PREPARED BY: P. Mitchell	DATE: 9-22-70			EFFECTIVITY: QUALIFICATION UNIT	
APPROVED: [signature]	DATE: 9/23/70				

ITEM NO.	CHARACTERISTIC	AQL	INSP. BUY-OFF	EQUIPMENT

REFERENCE: "Qualification Test Specifications and Procedures for Electrostatic Gravity Substitute Workbench NASA Dwg. No. 95M12015 Intended for Use in Skylab Experiment M 507" approved 8/20/70.

FAILURES - A failure shall be defined as any occurrence which results in the inability of the test specimen to perform its required functions within specified limits under the conditions and for the duration specified or when structural damage is revealed by visual inspection. In the event of failure, the following action shall be taken:

(a) The test shall be suspended and the experiment principal investigator notified.
(b) The cause of failure shall be determined by the Project Supervisor.
(c) If the failure is due to a component part, the part shall be replaced by an approved replacement.
(d) If the failure is due to marginal adjustment, the equipment shall be realigned as required.
(e) When the cause of the failure is determined and corrected, the extent of retesting of the failed test shall be determined as part of the corrective action prior to starting the retest and continuing the normal test plan.

NONCONFORMANCE DOCUMENTATION - Test anomalies or failures shall be reported on the Inspection Squawk Sheet and shall be cleared by NASA final disposition.

C-1

REV. NO.	SH NO.	DESCRIPTION	AUTHORITY	BY	DATE
A	2	Item 11 - add (Flight config. - no current meas.)	P. Mitchell	[initials]	10/2/70
	3	Items 15 and 16 - add (Flight config. - no current meas.)	P. Mitchell	[initials]	10/2/70
B	3	Revise sequence of Items 18 thru 45, add sh. 5 & 6 (Vibration Test only)	P. Mitchell	[initials]	10/12/70

(B)

QCI NO 95M12015	QUALITY CONTROL INSTRUCTIONS (CONTINUATION SHEET)	SHEET 2 OF 6

ITEM NO	CHARACTERISTIC	AQL	INSP BUY-OFF	EQUIPMENT
	TEST DATA - Test data shall be recorded by the operator on the appropriate Data Sheet (functional tests and EMI tests) and appended to this QCI. The individual Data Sheets shall be numbered to key with the Item Nos. listed below. Evidence of inspection buy-off shall be on these Data Sheets as well as on the applicable QCI Item No.			
	DIAGNOSTIC TESTING - Diagnostic tests and/or engineering evaluations may be conducted to analyze malfunctions or to develop data on anomalies. Reference to them will be made on the Inspec. Squawk Sheet and to the pages of the Engineers Notebook containing the detailed data.			
	The following are items of inspection for the Qualification Test:			
1	Visual inspection			QUAL. TEST SPEC. PARA. REF
2	Functional Test per Para. 3.3.1 and 3.3.2 Append. 1			
3	EMI Test per Append. II			3.15.1
4	Functional Test per Para. 3.3.1 and 3.3.2 Append. I (in chamber)			3.15.2b
5	Low temp. soak			3.15.2c
6	Functional Test per Para. 3.3.1 and 3.3.2 Append. I			3.15.2d
7	High temp. soak			3.15.2e
8	Functional Test per Para. 3.3.1 and 3.3.2 Append. I			3.15.2f
9	Visual inspection - post temp.			3.15.2g
10	Visual inspection - pre-altitude			3.15.3a
(A) 11	Functional Test per Para. 3.3.1 and 3.3.2 Append. I (Flight config. - no current meas.)			3.15.3a
12	Low pressure soak			3.15.3b
13	Medium pressure soak			3.15.3c
14	Medium pressure power on			3.15.3d

841-81200 -B REV. JULY 63

(B)

QCI NO	QUALITY CONTROL INSTRUCTIONS (CONTINUATION SHEET)	SHEET 3 OF 6
95M12015		

ITEM NO	CHARACTERISTIC	AQL	INSP BUY-OFF	EQUIPMENT
				QUAL. TEST SPEC. PARA. REF.
(A) 15	Functional Test per Para 3.3.1 and 3.3.2 Append. I (one location) and P/S temp. record (Flight config. - no current meas.)			3.15.3e
(A) 16	Ambient press. Functional Test per Para. 3.3.1 and 3.3.2 Appen.I (Flight config. - no current meas.)			3.15.3g
17	Visual Inspection			3.15.3h
(B) 18	Functional test per para. 3.3.1 Append. I on bench. ~~Install on vibration fixture~~			
19	Install shield and power supply on vibr. fixture, table top connected.			3.15.4a
20	Vehicle Dynamics Test-flight axis			3.15.4.1
21	Visual inspect, then install table top.			
22	Repeat VDT - flight axis			3.15.4.1
23	Functional test per para. 3.3.1 Append. I on bench.			
24	Install shield and power supply on vibration fixture, table top connected.			
25	VDT - tangential axis			3.15.4.1
26	Visual inspect, then install table top.			
27	Repeat VDT - tangential axis			3.51.4.1
28	Functional test per para. 3.3.1 Append. I on bench.			
29	Install shield and power supply on vibration fixture, table top connected.			
30	VDT - perpendicular axis			3.15.4.1

841-61209 -B REV. JULY 63

(B)

QCI NO 95M12015	QUALITY CONTROL INSTRUCTIONS (CONTINUATION SHEET)	SHEET 4 OF 6

ITEM NO	CHARACTERISTIC	AQL	INSP BUY-OFF	EQUIPMENT
				QUAL. TEST SPEC. PARA. REF.
31	Visual inspect, then install table top.			
32	Repeat VDT-perpendicular axis			3.15.4.1
33	Functional test per para. 3.3.1 Append. I on bench.			
34	Install shield and power supply on vibration fixture, table top connected.			
35	Sinusoidal Evaluation Test - perpendicular axis			3.15.4.2
36	Visual inspect, then install table top.			
37	Repeat SET - perpendicular axis			3.15.4.2
38	Functional test per para. 3.3.1 Append. I on bench.			
39	Install shield and power supply on vibration fixture, table top connected.			
40	SET - tangential axis			3.15.4.2
41	Visual inspect, then install table top			
42	Repeat SET-tangential axis			3.15.4.2
43	Functional test per para. 3.3.1 Append. I on bench			
44	Install shield and power supply on Vibration fixture, table top connected.			
45	SET - flight axis			3.15.4.2
46	Visual inspect, then install table top.			
47	Repeat SET - flight axis			3.15.4.2

QCI NO 95M12015	QUALITY CONTROL INSTRUCTIONS (CONTINUATION SHEET)	SHEET 5 OF 6

ITEM NO	CHARACTERISTIC	AQL	INSP BUY-OFF	EQUIPMENT
				QUAL. TEST SPEC. PARA. REF.
48	Functional test per para. 3.3.1 Append. I on bench			
49	Install shield and power supply on vibration fixture, table top connected.			
50	Lift-off Random Test - flight axis			3.15.4.3
51	Visual inspect, then install table top.			
52	Repeat LORT - flight axis			3.15.4.3
53	Functional test per para. 3.3.1 Append. I on bench			
54	Install shield & power supply on vibration fixture, table top connected.			
55	LORT - tangential axis			3.15.4.3
56	Visual inspect,then install table top.			
57	Repeat LORT - tangential axis			3.15.4.3
58	Functional test per para. 3.3.1 Append. I on bench			
59	Install shield and power supply on vibration fixture, table to connected.			
60	LORT - perpendicular axis			3.15.4.3
61	Visual inspect, then install table top			
62	Repeat LORT - perpendicular axis			3.15.4.3
63	Functional test per para. 3.3.1 Append. I on bench			
64	Install shield and power supply on vibration fixture, table top connected.			
65	Boost Random Test - perpendicular axis			3.15.4.4

(B)

QCI NO. 95M12015

QUALITY CONTROL INSTRUCTIONS
(CONTINUATION SHEET)

ITEM NO.	CHARACTERISTIC	AQL.	INSP. BUY-OFF	EQUIPMENT
				QUAL. TEST SPEC. PARA. REF.
66	Visual inspect, then install table top.			
67	Repeat BRT - perpendicular axis			3.15.4.4
68	Functional test per para. 3.3.1 Append. I on bench			
69	Install shield and power supply on vibration fixture, table top connected.			
70	BRT - tangential axis			3.15.4.4
71	Visual inspect, then install table top.			
72	Repeat BRT - tangential axis			3.15.4.4
73	Functional test per para. 3.3.1 Append. I on bench			
74	Install shield and power supply on vibration fixture, table top connected.			
75	BRT - flight axis			3.15.4.4
76	Visual inspect, then install table top			
77	Repeat BRT - flight axis			3.15.4.4
78	Install in Force Test Fixture, Functional Test per Para. 3.3.1 and 3.3.2 Append. I			3.15.4.5
79	Final Acceptance (Inspection Stamp Buy-off)			

APPENDIX D

TEST DATA SHEETS

FOR AN

ELECTROSTATIC GRAVITY SUBSTITUTE WORKSHOP

(QUALIFICATION TEST)

DATA SHEET NO. 4-1

DATE OF TEST 9/16/70

TEST BY ECD

UNIT QUAL

ELECTROSTATIC VOLTAGE TEST

Ref. Para. 3.3.1

CCSD IN-P 64

9-16-70

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	3.3	3
2	9.1	8
3	17	15
4	21.5	20

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	S/N NO.
ESVM	SINGER	ESH	9459431	015078

DATA: TAKEN PRIOR TO COLD TEST.
(INSTALLED IN CHAMBER)

Data taken prior to cold Test

(INSTALLED IN CHAMBER)

DATA SHEET 4-2

DATE OF TEST 9/16/70

TEST BY [illegible]

UNIT QUAL

ELECTROADHESIVE FORCE MEASUREMENT

Ref. Para. 3.3.2

CCSD M-P 64

9-16-70

INITIAL TABLE ORIENTATION d_o 13.5 ; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{HS} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.25	2.4		19	5.5	18.1	14.5
	2	0.27	2.1		19	5.5	18.1	
	3	0.23	2.3		18.5	5.0	15.8	
	4	0.25	2.4		18.0	4.5	13.8	
3	1	0.17	1.0		18.0	4.5	13.8	12.9
	2	0.17	1.2		17.0	3.5	10.2	
	3	0.18	1.1		18.0	4.5	13.8	
	4	.19	1.0		18.0	4.5	13.8	
2	1	0.11	0.11		15	1.5	4.1	5.6
	2	0.12	0.20		15.5	2.0	5.6	
	3	.13	.17		16	2.5	6.3	
	4	.13	.17		16	2.5	6.3	
1	1	.1	.007		14.75	1.25	3.4	3.1
	2	.1	.006		14.75	1.25	3.4	
	3	.12	.002		14.5	1.0	2.7	
	4	.12	.002		14.25	.75	2.1	

ORIENT TABLE 180° [illegible], d_o = 13.5

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{HS} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	.20	2.7		18	4.5	13.8	23.8
	2	.20	2.0		19	5.0	15.8	
	3	0.2	2.3		21	7.5	32.8	
	4	0.18	2.1		21	7.5	32.8	
3	1	.12	1.1		20.5	7.0	27.8	24.7
	2	.12	1.0		20.5	7.0	27.8	
	3	.13	1.0		19.5	6.0	20.8	
	4	.12	1.2		19.75	6.25	22.3	

DATA SHEET NO. 4-3

DATE OF TEST 9/16/70

TEST BY LCB

UNIT QUAL

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED)

Ref. Para. 3.3.2

CCSD IN-P 64

9-16-70

Data taken prior To cold test (INSTALLED IN CHAMBER)

ORIENT TABLE 180°

S-2 POS.	BEAM NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1	.05	.13		15.5	2.0	5.6	10.4
	2	.05	.15		17.5	4.0	11.9	
	3	.06	.17		18.5	5.0	15.8	
	4	.06	.17		16.5	3.0	8.6	
1	1	.037	.009		16.0	2.5	7.0	5.9
	2	.038	.006		15.5	2.0	5.6	
	3	.037	.006		15.5	2.0	5.6	
	4	.034	.008		15.5	2.0	5.6	

S-2 POS	AVG FORCE
4	19.1
3	18.8
2	8.0
1	4.5

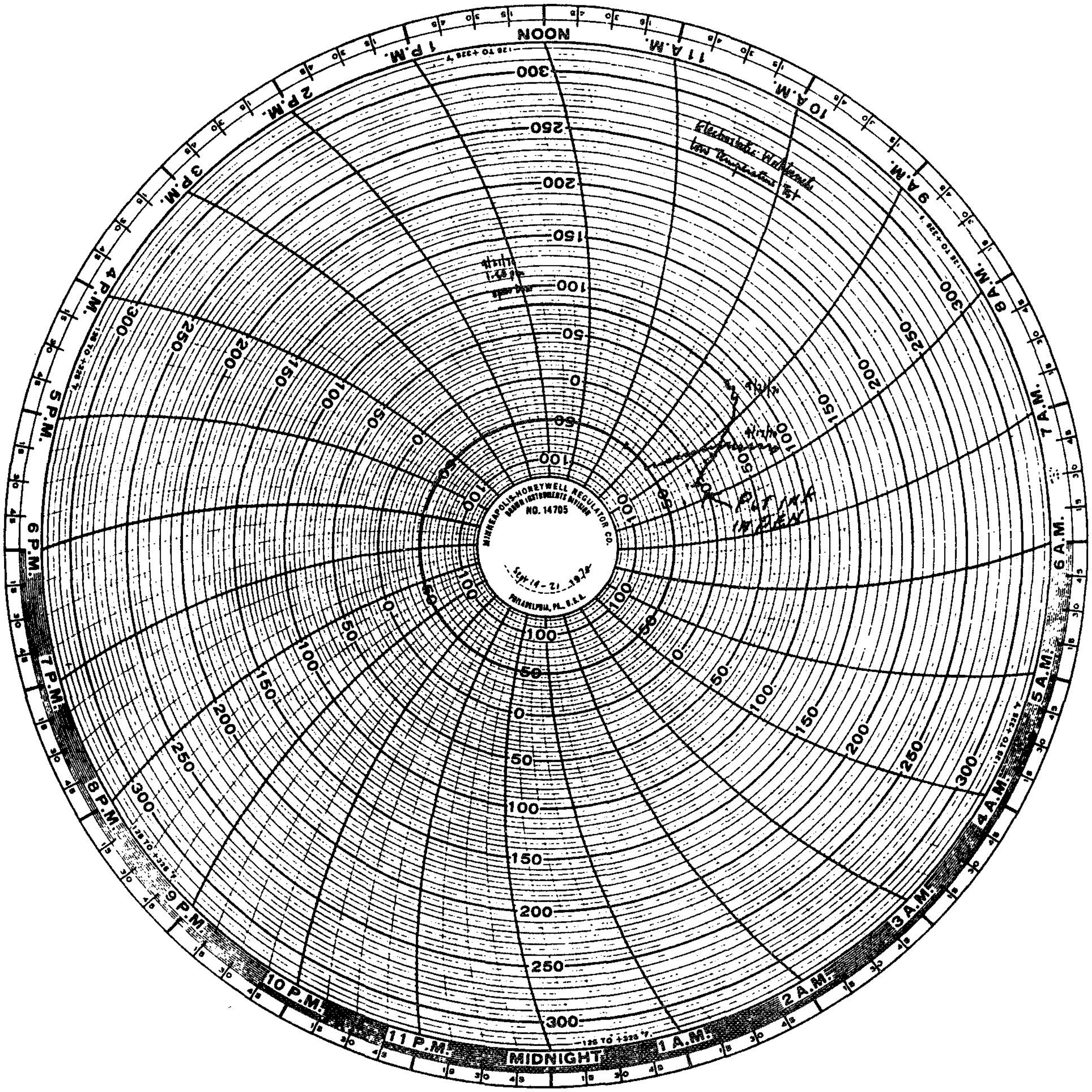

Chart 5-1. Low Temperature Record

DATA SHEET NO. 6-1

DATE OF TEST SEPT 28-70

TEST BY Eugene McPherson

UNIT QUALIFICATION UNIT

ELECTROSTATIC VOLTAGE TEST, POST LOW TEMP & BEFORE HEAT RUN.

Ref. Para. 3.3.1

REF: APPENDIX III

SUPPLY (V_s) = 28.0.

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	OUTSIDE OF HOLE. AT CENTER OF SCREEN (KV) 1.5	3
2	6.4	8
3	15.3	15
4	22.1	20.

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.
ESVM	SINGER	ESH	945943	015078
VOM	SIMPSON	269		010306

Ref. Squawk ESWB-0037

DATA SHEET NO. 6-2

DATE OF TEST Sept 28-70

ELECTROADHESIVE FORCE MEASUREMENT POST LOW TEMP. BEFORE HEAT RUN

TEST BY Eugene J MacPherson

Ref. Para. 3.3.2 REF:

UNIT QUALIFICATION UNIT

INITIAL TABLE ORIENTATION (4:00 o'clock) d_o = 13.37 EJM; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.154	0.44		20 3/4	7.4	31.4	38.6
	2	0.153	0.43		21 1/4	7.9	37.6	
	3	0.154	0.43		21 3/8	8.0	39.5	
	4	0.153	0.43		21 7/8	8.3	45.0	
3	1	0.111	0.323		19 7/8	6.5	23.95	26.7
	2	0.111	0.323		19 5/8	6.2	22.3	
	3	0.111	0.323		19 3/4	6.4	23.1	
	4	0.112	0.323		21 1/4	7.9	37.6	
2	1	0.061	0.189		17 1/4	3.9	11.5	17.7
	2	0.061	0.196		18 3/4	5.4	17.5	
	3	0.061	0.190		18 5/8	5.3	17.0	
	4	0.061	0.190		20 -	6.6	24.8	
1	1	0.036	0.124		18 1/8	4.9	15.3	14.4
	2	0.036	0.125		17 1/2	4.1	12.3	
	3	0.036	0.125		17 5/8	4.3	12.8	
	4	0.036	0.125		17 5/8	4.3	12.8	

ORIENT TABLE 180° (10:00 o'clock) d_o = 13.37 EJM

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.140	0.44		21 3/4	8.4	49	59
	2	0.153	0.43		22 3/8	9.0	67	
	3	0.152	0.43		22 1/4	8.9	64	
	4	0.145	0.42		22 -	8.6	56	
3	1	0.105	0.31		21 1/4	7.9	37.6	35.5
	2	0.106	0.32		21 -	7.6	34.2	
	3	0.106	0.32		21 -	7.6	34.2	
	4	0.112	0.32		21 -	7.6	34.2	

DATA SHEET NO. 6-3

DATE OF TEST Sept 28-70

TEST BY [signature]

QUALIFICATION UNIT

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED)

Ref. Para. 3.3.2

POST LOW TEMP.
& BEFORE HEAT RUN

ORIENT TABLE 180°

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1	0.058	0.185	—	18 —	4.6	14.3	
	2	0.058	0.184	—	18 5/8	5.2	16.9	16.9
	3	0.058	0.185	—	18 3/4	5.4	17.5	
	4	0.058	0.185	—	18 3/8	5.0	15.8	
1	1	0.034	0.120	—	16 3/4	3.4	9.8	
	2	0.034	0.121	—	16 5/8	3.3	9.4	8.6
	3	0.034	0.122	—	16 3/8	3.0	8.6	
	4	0.034	0.122	—	15 3/4	2.4	6.7	

INSTRUMENTS	MAKE	MODEL	SERIAL	B/T NO
VOM	SIMPSON	269		010306
DIFFERENTIAL	FLUKE	803B	3116	017807
TEST FIXTURE	CCSD	—	—	—

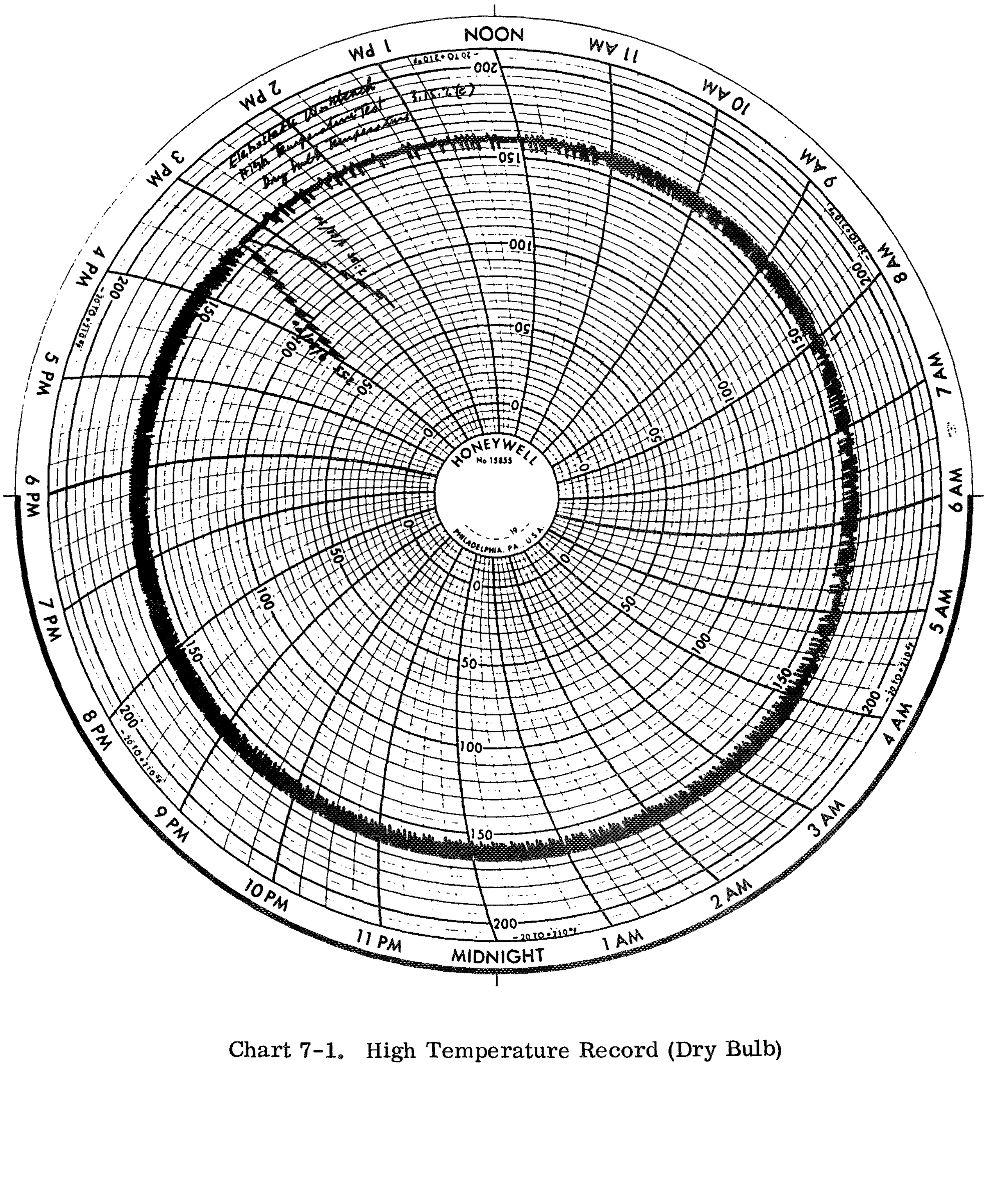

Chart 7-1. High Temperature Record (Dry Bulb)

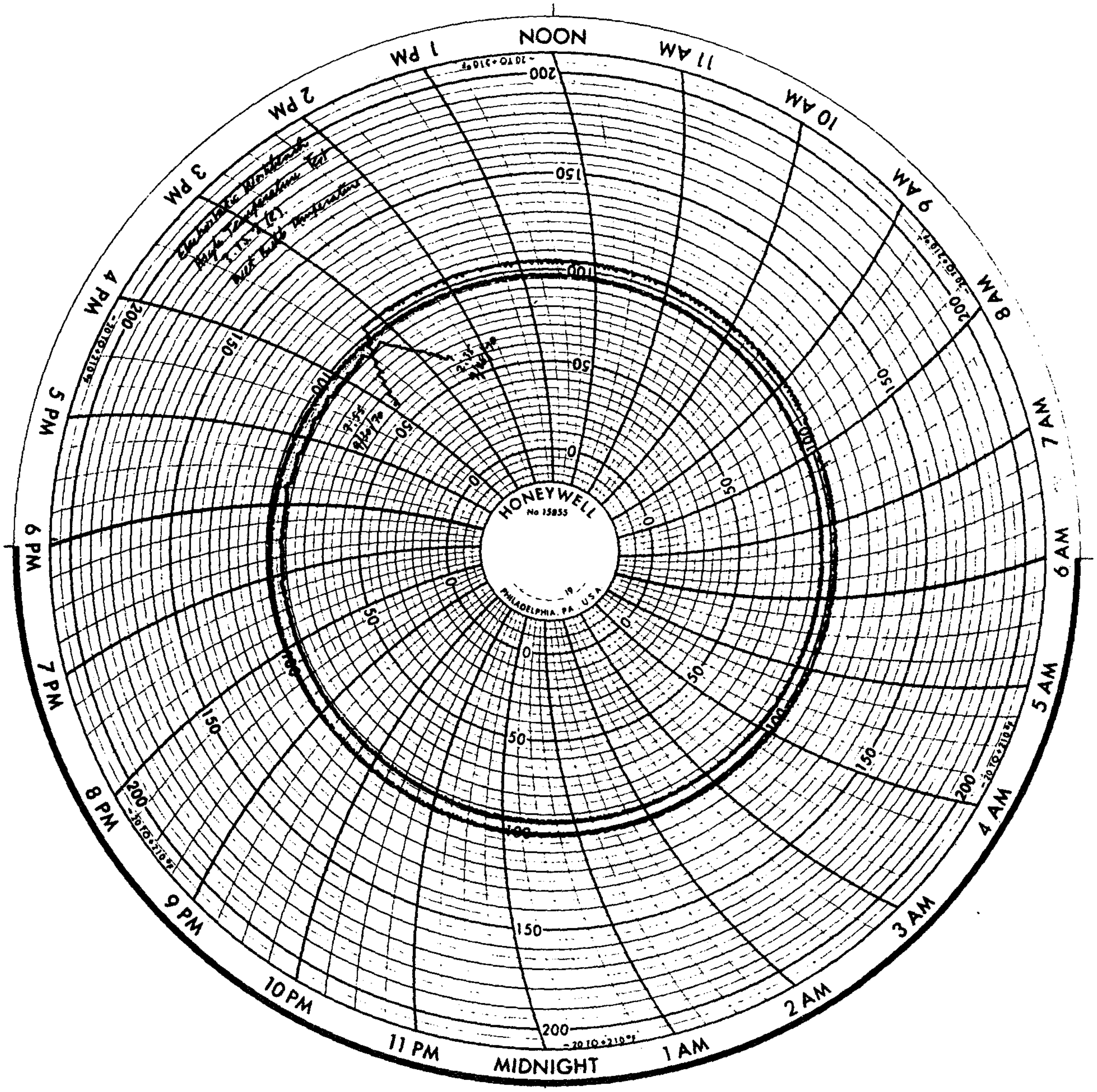

Chart 7-2. High Temperature Record (Wet Bulb)

DATA SHEET NO. 8-1

DATE OF TEST 10-1-70.

ELECTROSTATIC VOLTAGE TEST, POST HIGH. TEMP

TEST BY Eugene McPherson

Ref. Para. 3.3.1

UNIT Qual. unit

SUPPLY VOLTS V_s = 28.0.

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE (KV)	MIN. REQUIREMENT
1	2.51	3
2	7.15	8
3	16.8	15
4	22.9	20

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.
[illegible]	SINGER	ESH.	145931	015078

Ref. Squawk ESWB-0038

ESWB-0038 is withdrawn as a result of Procedure change Rev. C which changed the minimum requirement for switch S2 positions 1 and 2 to 1.3 and 6.0 KV respectively.

DATA SHEET NO. 8 - 2

DATE OF TEST 10-1-70.

TEST BY Eugene L. McPherson

UNIT QUALIFICATION

Taken at 4:00 o'clock

ELECTROADHESIVE FORCE MEASUREMENT POST HIGH TEMP

RUN DISCONTINUED BECAUSE OF COAXIAL CABLE TROUBLE

Ref. Para. 3.3.2

See attached data sheet with cable replacement E.L.M.

TABLE A7 4:00 o'clock

INITIAL TABLE ORIENTATION $d_o = 13.5$; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (~~mA~~) μA	LEAKAGE CURRENT I_L (~~mA~~) μA	SUPPLY CURRENT I_{ES}(mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.140	2.110	—	21 —	7.5		
	2	0.140	1.960	—	21 —	7.5		
	3	0.138	1.964	—	21 1/2	8.0		
	4	0.138	1.990	—	21 1/4	7.7		
3	1	0.043	0.970		18 —	5.5		
	2	0.042	0.970	—	20 1/4	6.7		
	3	0.057	0.870	—	20 7/8	7.4		
	4	0.048	0.920		21 1/8	7.6		
2	1	0.0	0.086					
	2	ZERO	READING -	COAXIAL CA	BLE	TROUBLE		
	3							
	4							
1	1							
	2							
	3							
	4							

ORIENT TABLE 180° d_o = ______

S2 POS.	READ NO.							
4	1							
	2							
	3							
	4							
3	1							
	2							
	3							
	4							

DATA SHEET NO. 8-2a

DATE OF TEST 10-1-70

ELECTROADHESIVE FORCE MEASUREMENT POST-HIGH TEMP

TEST BY Eugene L. McPherson

Ref. Para. 3.3.2

UNIT QUALIFICATION

THIS RUN WITH A REPLACEMENT OF COAXIAL CABLE.

TABLE AT 4:00 O'CLOCK

INITIAL TABLE ORIENTATION d_o = 13.5 ; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.099	2.30		21 5/8	8.1	41.0	34.4
	2	0.133	1.970		21 5/8	8.1	41.0	
	3	0.129	1.970		21 1/2	7.0	27.8	
	4	0.120	1.910		21 1/2	7.0	27.8	
3	1	0.043	0.830		20 3/8	6.9	26.8	39.0
	2	0.045	0.840		20 3/4	7.2	30.1	
	3	0.047	0.820		20 3/4	7.2	30.1	
	4	0.046	0.842		20 3/4	7.2	30.1	
2	1	0.0063	0.030		17 3/8	3.9	11.5	12.0
	2	0.0063	0.055		17 1/2	4.0	11.9	
	3	0.0093	0.058		17 1/2	4.0	11.9	
	4	0.0093	0.113		17 3/4	4.2	12.8	
1	1	0.0033	0.006		16 3/8	2.9	8.2	8.5
	2	0.0034	0.000000		16 1/2	3.0	8.6	
	3	0.0160	0.000000		16 1/2	3.0	8.6	
	4	0.0035	0.0171		16 1/2	3.0	8.6	

ORIENT TABLE 180° d_o = 13.5 TABLE AT 10:00 O'CLOCK

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.120	2.200		17 1/2	4.0	11.9	14.5
	2	0.130	1.825		17 7/8	4.4	13.2	
	3	0.120	1.854		17 1/4	3.8	11.0	
	4	0.136	1.830		19 3/8	5.9	20.1	
3	1	0.042	0.590		18 5/8	5.1	16.4	14.7
	2	0.043	0.554		18 —	4.5	13.8	
	3	0.0495	0.854		18 1/4	4.7	14.8	
	4	0.0494	0.830		18 —	4.5	13.8	

DATA SHEET NO. 8-7

DATE OF TEST 10-1-70

TEST BY Eugene Smithers

UNIT QUALIFICATION

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED) POST HIGH TEMP.

Ref. Para. 3.3.2

ORIENT TABLE 180°

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1	0.004	0.0495	-	15 5/8	2.1	5.9	9.4
	2	0.004	0.0620		17 1/8	3.6	10.6	
	3	0.0076	0.0590		17 1/8	3.6	10.6	
	4	0.0090	0.0595		17 1/8	3.6	10.6	
1	1	0.0024	0.0010		15 5/8	2.1	5.9	7.7
	2	0.0043	0.0006		15 5/8	2.1	5.9	
	3	0.0030	0.0003		16 5/8	3.1	8.9	
	4	0.0133	0.0003		16 1/2	3.0	8.6	

DATA SHEET NO. 11-1

DATE OF TEST OCT 8-70.

TEST BY Eugene L McPherson

UNIT [illegible]

ELECTROSTATIC VOLTAGE TEST

Ref. Para. 3.3.1

$V_s = 28.00$

11'40 AM

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE (kV)	MIN. REQUIREMENT
1	6.2	1.3
2	9.3	6
3	16.0	15
4	22.4	2[illegible]

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.
F[illegible]VM	[illegible]	[illegible]		

DATA SHEET NO. 11-2

DATE OF TEST OCT 8-70

TEST BY Eugene McPherson

UNIT QUALIFICATION

ELECTROADHESIVE FORCE MEASUREMENT

Ref. Para. 3.3.2

INITIAL TABLE ORIENTATION 10:00 K d_o = 13.5 ; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
3	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
2	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
1	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	

ORIENT TABLE 180° 4:00 K d_o = 13.5

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1				13.5	0	0	0.3
	2				13.5	0	0	
	3				13.5	0	0	
	4				14.0	0.5	1.4	
3	1				13.5	0	0	
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	

Ref ESWR 0040

DATA SHEET NO. M-3

DATE OF TEST OCT 8-70

TEST BY Eugene L McPherson

UNIT QUALIFICATION

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED)

Ref. Para. 3.3.2

Ref. ESWB-004D

ORIENT TABLE 180°

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
1	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	

DATA SHEET NO. 15-1

DATE OF TEST OCT 9/70

TEST BY Eugene L McPherson

ELECTROSTATIC VOLTAGE TEST

UNIT QUALIFICATION

Ref. Para. 3.3.1

Vacuum changed from 0 PSI (14 MICRONS) to 5 PSI

7:55 to 8:14 AM.

PWR ON 8:14 AM.

START: AMBIENT TEMP 112°F

PWR SUPP 112°F.

TIME	SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE (KV)	MIN. REQUIREMENT	TEMP PWR SUPP (DEG F)
10:30	1	6.80	1.3	112.
10:03	2	12.2.	6	112.
9:36	3	17.9	15	112.
9:15 AM	4	25.5	20	112

SUPPLY VOLTAGE (V_s) = 28.0.

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.
~~SINGER~~ E SUM	~~ES~~ SINGER	ESH		015078

DATA SHEET NO. 15-2

DATE OF TEST OCT 9/70

TEST BY Eugene J McPherson

UNIT QUALIFICATION

ELECTROADHESIVE FORCE MEASUREMENT

Ref. Para. 3.3.2

$V_s = 28.0.$

INITIAL TABLE ORIENTATION 04:00 K d_o = 13.5 ; $D = d_B - d_o$

POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
3	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
2	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
1	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	

COMPLETED 10:30 AM

d_o = ____

~~ORIENT TABLE 180°~~

POS.	READ NO.						
4	1						
	2						
	3						
	4						
3	1						
	2						
	3						
	4						

Ref ESWB-0041

DATA SHEET NO. 16-1

DATE OF TEST OCT 9/70

TEST BY Eugene L McPherson

ELECTROSTATIC VOLTAGE TEST POST VACUUM

UNIT QUALIFICATION

Ref. Para. 3.3.1

RETURNED TO AMBIENT AT 10:37 AM.
PRESSURE 14.5 PSI
V_s = 28.0.
TABLE AT 04:00K POSITION

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE (KV.)	MIN. REQUIREMENT (KV.)
1	3.68	1.3
2	7.75	6
3	15.0	15
4	21.2	20

INSTRUMENT

INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.

DATA SHEET NO. 16-2

DATE OF TEST OCT 9/70

TEST BY Eugene L McPharon

ELECTROADHESIVE FORCE MEASUREMENT POST VACUUM.

UNIT QUALIFICATION

Ref. Para. 3.3.2 START TEST 10:50

AMBIENT PRESSURE 14.5 PSI

INITIAL TABLE ORIENTATION: 04:00 K d_o = 13.5 ; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
3	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
2	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	
1	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	

COMPARISON OF BEHAVIOR OF STRING & DISC AT PULL AWAY FOR SW S2 POSITIONS 3 & 4 WITH ~~[illegible]~~ BEHAVIOR FOR POSITION 1 SEEMS TO INDICATE A DIFFERENCE. THERE MAY BE A SMALL ORDER OF PULL BUT NOT AN AMOUNT MEASURABLE BY THIS APPARATUS

Eugene L McPharon

ORIENT TABLE 180° 10:00 K d_o = 13.5

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1				13.5 X	X 0	0	0
	2				13.5 X	X 0	0	
	3				13.5 X	0	0	
	4				13.5 X	0	0	
3	1				13.5 X	0	0	0
	2				13.5 X	0	0	
	3				13.5 X	0	0	
	4				13.5 X	0	0	

X Approximately ZERO, BUT A SMALL TRACE OF PULL

Ref ESWB-0042

DATA SHEET NO. 16-3

DATE OF TEST OCT 9/70

TEST BY Eugene L McPherson

UNIT QUALIFICATION

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED)

Ref. Para. 3.3.2 POST VACUUM

Ref ESWB-0042

ORIENT TABLE 180° : 00:00 K.

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1	X A SMALL	TRACE OF	PULL	13.5X	0	0	0
	2	NOT ME	ASURABLE		13.5X	0	0	
	3				13.5X	0	0	
	4				13.5X	0	0	
1	1				13.5	0	0	0
	2				13.5	0	0	
	3				13.5	0	0	
	4				13.5	0	0	

DATA SHEET NO. 13

DATE OF TEST OCT 13-70

TEST BY Eugene L McPherson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE (KV)	MIN. REQUIREMENT
1	> 2.2.	1.7
2	> 8.2.	6
3	> 18	15
4	> 23.6.	20

$V_s = 28.0$ V

INSTRUMENT

CALIB. DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	ESH.	945931	015078	FIELD VOLTAGE
10-20-70	VOM	SIMPSON	260		018397	V_s
5-13-71		LAMBDA	LA 20-05BM	12141	016967	V_s

DATA SHEET NO. 27

DATE OF TEST OCT 13/70

ELECTROSTATIC VOLTAGE TEST AFTER VDT-FLIGHT AXIS REF

TEST BY Eugene L McPherson

Ref. Para. 3.3.1

UNIT QUALIFICATION

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	> 2.7	1.3
2	> 8.2	6
3	> 17.0	15
4	22.7	20

$V_s = 28.0^v$

INSTRUMENT

CALIB. DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	~~SINGER~~ ESM	SINGER	ESH	945931	015078	FIELD VOLTAGE
10-20-70	VOM	SIMPSON	260	—	018397	V_s
5-13-71	PWR SUPP.	LAMBDA	LA20-05 BM	12141	016967	V_s

DATA SHEET NO. 33

DATE OF TEST OCT 28/70

TEST BY Eugene L. McPherson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST AFTER QC1 23.

Ref. Para. 3.3.1

$V_s = 28.0$

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	24.0	1.3
2	28.5	6.0
3	17.4	15.0
4	24.0	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER.
1-29-71	ESVM	SINGER	E.SH	945931	015078	FIELD VOLTAGE
E/m 4-22-71 ~~10-20-70~~	VOM	SIMPSON	260	—	018397	V_s
5-13-71	PWR SUPP	LAMBDA	LA 20-05 BM	12141	016967	V_s

DATA SHEET NO. 38

DATE OF TEST OCT 28/70

TEST BY Eugene [illegible]

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST AFTER ~~VDT~~ SET IN PERPENDICULAR AXIS

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	4.5	1.3
2	8.2.	6.0
3	16.5	15.0
4	22.7	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	ESH	945931	015075	FIELD VOLTAGE
10-20-70	VOM	SIMPSON	260	—	018397	V
5-13-71	PWR SUPP	LAMBDA	LA 20-05 BM	12141	016967	Vs

DATA SHEET NO. 43

DATE OF TEST OCT 28/70

TEST BY Eugene L Matheson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST AFTER "SET" IN TANGENTIAL AXIS.

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	> 4.2	1.3
2	> 8.2	6.0
3	16.7	15.0
4	24.0	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	E.S.H	945931	015075	FIELD VOLTAGE
10-20-70	VOM	SIMPSON	260	—	018397	V_s
5-13-71	PWR SUPP	LAMBDA	LA 20-05 BM	12141	016967	V_s

DATA SHEET NO. 48

DATE OF TEST OCT 28/70

TEST BY Eugene L McPherson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST AFTER SET IN FLIGHT AXIS

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	> 3.7	1.3
2	> 8.0	6.0
3	16.5	15.0
4	23.5	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	E SH	945931	015075	FIELD VOLTAGE
EJM ~~[illegible]~~ 4-22-71	VOM	SIMPSON	260	—	018397	V_s
5-13-71	PWR SUPP	LAMBDA	LA 20—05 BM	12141	016967	V_s

DATA SHEET NO. 3 2

DATE OF TEST OCT 29/70

TEST BY Eugene L McPherson

UNIT QUALIFICATION.

ELECTROSTATIC VOLTAGE TEST AFTER LORT IN FLIGHT AXIS

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	> 4.10	1.3
2	> 8.40	6.0
3	17.2	15.0
4	24.0	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	E.SH	945931	015078	FIELD VOLTAGE
10-20-70	VOM	SIMPSON	260	—	018397	V
5-13-71	PWR SUPP	LAMBDA	LA 20—05 BM	12141	016967	V

DATA SHEET NO. 58

DATE OF TEST OCT 29/70

ELECTROSTATIC VOLTAGE TEST AFTER LORT - TANGENTIAL AXIS.

TEST BY Eugene L McPherson

Ref. Para. 3.3.1

UNIT QUALIFICATION.

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	4.7	1.3
2	8.8	6.0
3	17.4	15.0
4	24.0	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER [illegible]
1-29-71	ESVM	SINGER	ESH	945931	015078	FIELD [illegible]
10-20-70	VOM	SIMPSON	260	—	018397	V
5-13-71	PWR SUPP	LAMBDA	LA 20 — 05 BM	12141	016967	V

DATA SHEET NO. 63

DATE OF TEST OCT 29/70

TEST BY Eugene McPherson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST AFTER LORT-PERPENDICULAR AXIS

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	>4.1	1.3
2	>8.1	6.0
3	16.5	15.0
4	22.6	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	ESH	945931	015078	FIELD VOLTAGE
10-20-70	VOM	SIMPSON	260	—	018397	V_s
5-13-71	PWR SUPP	LAMBDA	LA 20-05 BM	12141	016967	V_s

DATA SHEET NO. 68

DATE OF TEST OCT 29/70

TEST BY Eugene L McPherson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST, AFTER BRT - PERPENDICULAR AXIS

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	> 4.45	1.3
2	> 8.50	6.0
3	>16.50	15.0
4	> 22.50	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	ESH	945931	015078	FIELD V
10-20-70	VOM	SIMPSON	260	—	018397	V
5-13-71	PWR SUPP	LAMBDA	LA 20 — 05 BM	12141	016967	V

DATA SHEET NO. 15

DATE OF TEST OCT 30/70

TEST BY Eugene L McPherson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST AFTER BRT-TANGENTIAL AXIS.

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	> 4.2	1.3
2	> 9.5	6.0
3	17.4	15.0
4	23.7	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAM[illegible]
1-29-71	ESVM	SINGER	ESH	945931	015075	FIELD [illegible]
10-20-70	VOM	SIMPSON	260	—	018397	V
5-13-71	PWR SUPP	LAMBDA	LA 20-05 BM	12141	016967	V

DATA SHEET NO. 78-1

DATE OF TEST OCT 30/70

TEST BY Eugene L McPherson

UNIT QUALIFICATION

ELECTROSTATIC VOLTAGE TEST AFTER

Ref. Para. 3.3.1

SWITCH S2 POSITION	ELECTROSTATIC FIELD VOLTAGE	MIN. REQUIREMENT
1	> 4.2	1.3
2	~~7.9~~ > 9.0 ELm	6.0
3	17.7	15.0
4	23.6	20.0

INSTRUMENT

CALIB DUE DATE	INSTRUMENT	MAKE	MODEL	SERIAL	B/T NO.	PARAMETER
1-29-71	ESVM	SINGER	ESH	945931	015078	FIELD VOLTAGE
ELm 4-22-71 ~~[illegible]-70~~	VOM	SIMPSON	260	—	018397	V
5-13-71	PWR SUPP	LAMBDA	LA 20—05 BM	12141	016967	Vs

DATA SHEET NO. 78-2

DATE OF TEST OCT 30/70

Eugene L McPherson

UNIT QUALIFICATION

ELECTROADHESIVE FORCE MEASUREMENT

Ref. Para. 3.3.2

04:00 O'CLOCK POSITION OF TERMINAL BLOCK

INITIAL TABLE ORIENTATION $d_o = 13\frac{5}{8}$; $D = d_B - d_o$

S2 POS.	READ NO.	TABLE CURRENT I_T (~~mA~~) μA	LEAKAGE CURRENT I_L (~~mA~~) μA	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.17~~8~~	2.8	—	135/8	0	0	
	2	0.13~~0~~	2.8		135/8	0	0	0
	3	0.13~~8~~	2.8		135/8	0	0	
	4	0.13~~4~~	2.7		135/8	0	0	
3	1	0.08	1.6		135/8	0	0	
	2	0.08	1.6		135/8	0	0	0
	3	0.08	1.5		135/8	0	0	
	4	0.07	1.6		135/8	0	0	
2	1	0.007	0.195		135/8	0	0	
	2	0.003	0.212		135/8	0	0	0
	3	0.004	0.250		135/8	0	0	
	4	0.007	0.250		135/8	0	0	
1	1	0.0055	0.022		135/8	0	0	
	2	0.0060	0.044		135/8	0	0	0
	3	0.0060	0.027		135/8	0	0	
	4	0.0060	0.020		135/8	0	0	

10:00 O'CLOCK POSITION OF TABLE TERMINAL BLOCK

ORIENT TABLE 180° $d_o = 13\frac{5}{8}$

S2 POS.	READ NO.	TABLE CURRENT I_T μA	LEAKAGE CURRENT I_L μA	SUPPLY CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms	AVG. gms.
4	1	0.10	2.90		135/8	0	0	
	2	0.15	2.90		135/8	0	0	0
	3	0.13	2.53		135/8	0	0	
	4	0.20	2.53		135/8	0	0	
3	1	0.047	1.38		135/8	0	0	
	2	0.068	1.34		135/8	0	0	0
	3	0.068	1.44		135/8	0	0	
	4	0.073	1.44		135/8	0	0	

ELECTROADHESIVE FORCE MEASUREMENT (CONTINUED)

Ref. Para. 3.3.2

DATE OF TEST OCT 30/7

TESTED BY Eugene McPherson

UNIT QUALIFICATION

ORIENT TABLE 180°

S2 POS.	READ NO.	TABLE CURRENT I_T (mA)	LEAKAGE CURRENT I_L (mA)	SUPPLY·CURRENT I_{ES} (mA)	DIST. d_B	DIST. D	FORCE gms.	AVG. gms.
2	1	0.0120	0.167		13 5/8	0	0	0
	2	0.0160	0.169		13 5/8	0	0	
	3	0.0160	0.190		13 5/8	0	0	
	4	0.0170	0.200		13 5/8	0	0	
1	1	0.006	0.046		13 5/8	0	0	0.
	2	0.007	0.025		13 5/8	0	0	
	3	0.008	0.100		13 5/8	0	0	
	4	0.005	0.023		13 5/8	0	0	

APPENDIX E

INSPECTION SQUAWK SHEETS

for an

ELECTROSTATIC GRAVITY SUBSTITUTE WORKBENCH

(QUALIFICATION UNIT)

616-6148C
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SHEET 1 OF 2

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

SPACE DIVISION **CHRYSLER CORPORATION**

NO.	ASSEMBLY NO.	REV.
ESWB-0037	95M12015	

STAGE NO	ASSY. NAME	SERIAL NO.
	Electrostatic Work Bench Assy	Qualification UNIT

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
6.1	9/30/70	1	95M12015	Ref. Data Sheet No. 6-1 QCI 95M12015	E03			CCSD IN-64
1	R.M.	1	ESWB Qual. Unit	with Switch S2 in position	DE			10-[illegible]
				1 and 2 The minimum requirement				
				is 3.0 and 8.0 KV respectively				
				Actual voltages at position				
				1 and 2 are 1.5 and 6.4 KV.				
				NASA: QPA concurs in the above				
				as listed. 9/30/70				
				Gavin E. Turner				
				The corresponding forces to these 2 discrepant ESVM				
				readings are good, indicating acceptable system				
				function.				
				RECOMM. ACTION: Use as is. P. [illegible] 10/2/70				
			DISPOSITION REJECTED.					
			NASA QPA RECOMMENDS:	IF THE MINIMUM REQUIREMENTS CANNOT BE MET THE REQUIREMENTS IN THE PROCEDURE SHOULD BE CHANGED.				
				Orval L. Leytham				
				PM-MA-QPA 10/5/70				
				The spec. min. requirement is being changed to 1.3 & 6.0KV				
				for S2 pos. 1 & 2 respectively; add "between holes"				
				to probe location. P. [illegible] 10/6/70				

616-R1480
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SHEET 2 OF 2

- [ ] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

SPACE DIVISION **CHRYSLER CORPORATION**

NO.	ASSEMBLY NO.	REV.
ESWB-0037	95M12015	
STAGE NO	ASSY. NAME	SERIAL NO.

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
				NASA PM-MA-QPA Recommends:				
				Use The changes CCSD Recommended				
				For The spec. Dated 10/6/70				
				R L Leyton 10/2/70				
				CONCURRED IN BY J.B. RENDALL S&E-ME-MX PER				
				TELECON 10-8-70 Harvey R. Stewart, Jr. PM-MA-QAC				

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SHEET 1 OF 2

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

SPACE DIVISION CHRYSLER CORPORATION

NO.	ASSEMBLY NO.	REV.
ESWB-0040	9v-M1201v	

STAGE NO	ASSY. NAME	SERIAL NO.
	Electrostatic Weakthrough Assy	Qualification unit

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2v31

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
QCI 9v-M1201v 11,2+3	10-8-70	1	9v-M1201v	The data findings during	E03			ECSD IN-P 54
1	R.D.	1	ESWB Qual. Unit	functional Test No. 11-2 and	DE			11-3-70
				11-3 per QCI 9v-M1201v				
				indicates The pull aquired				
				for positions 4, 3, 2, and 1 of				
				switch S2 were found To be				
				(0) zero.				
				(exception - when Table Top was				
				rotated 180° with				
				switch S2 in position				
				4 one of The four				
				attempts showed pull				
				making The average				
				force in grams for				
				This one Test 0.3.)				
				Minimum Requirement for This				
				Test for positions 4,3,2, and 1				
				of S2 are 11, 8, 3, and no requirement				
				Respectively.				
				NASH PM-MA-QPA concurs in the				
				above squawk [illegible] 11/9/70				
				(SEE PG 2 OF 2)				

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616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual Unit

SHEET 2 OF 2

☐ SUPPLIED ITEM
☐ R & D ITEM
☐ GFE

SPACE DIVISION — CHRYSLER CORPORATION

NO.	ASSEMBLY NO.	REV.
ESWB-0040	95M12015	

STAGE NO	ASSY. NAME	SERIAL NO.
	ESWB. Assy	Qual unit

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION: DEF. CODE / RESP. CODE	DISPOSITION: RECOMM. ACTION / CORRECTED BY	DISPOSITION: QTY. ACCEPT / QTY REJECT	FINAL: DATE & INSPECTION STAMP
				RECOMM. ACTION: USE AS IS (REF 02 TO ESWB 0052) Concur with Use As Is Disposition refer to Squawk ESWB0052		P. [illegible] 11-13-70 / J B [illegible] 11/13/70		QCSD N-P 64 11-13-70

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SPACE DIVISION **CHRYSLER CORPORATION**

SHEET 1 OF 1

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

NO.	ASSEMBLY NO.		REV.
ESWB-0041	95M12015		
STAGE NO	ASSY. NAME	SERIAL NO.	
	Electrostatic workbench Assy	Qualification unit	

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION: DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL: DATE & INSPECTION STAMP
QCI 95M12015 IV.2	R.A.	1	95M12015	The data findings during functional	E03			CCSD N-P 64
1	10-9-70	1	ESWB. Qual Unit	Test No. IV-2 per QCI 95M12015	DE			11-13-70
				indicates The pull ~~[illegible]~~ for				
				S2 positions 4, 3, 2, and 1 is				
				(0) zero.				
				Requirement for positions 4, 3, 2 and 1				
				are an average of 11, 8, 5, and				
				no requirement respectively.				
				NASA PMMA-QPA CONCURS IN THE				
				above squawk [signature] 10/9/70				
				RECOMM. ACTION: USE AS IS (REFER TO ESWB 0052) P. Theobald 11-13-70				
				Concur with use as is disposition refer to ESWB 0052 - A.B. Rendall 11/13/70				

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SHEET 1 OF 1

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

SPACE DIVISION CHRYSLER CORPORATION

NO.	ASSEMBLY NO.	REV.
ESWB-0042	9VM12015	
STAGE NO	ASSY. NAME: Electrostatic workbench Assy	SERIAL NO.: Qualification un. T

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2V31

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
QCI 9VM1201V 16.2&3	10-9-70	1	9VM1201V	The data taken for Functional	E03			CCSD IN-P 64
1	R.D.	1	ESWB Qual. Unit	Test No. 16.2 and 3 per QCI	DE			11-13-70
				9VM1201V indicates that the				
				average force in grams for				
				S2 positions 4, 3, 2, and 1 is				
				(0) zero.				
				Requirement for this test is				
				11, 8, 3, and no requirement for				
				S2 positions 4, 3, 2 and 1 respectively.				
				NASA PM-MA-QPA Concurs in The above				
				Squawk: O.K. [signature] 10/9/70				
				RECOMM. ACTION: USE AS IS (REFER TO ESWB 0052) [signature] 11-13-70				
			Concur with Use As Is disposition refer to ESWB 0052 [signature] 11/13/70					

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SPACE DIVISION **CHRYSLER CORPORATION**

SHEET 1 OF 1

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

NO.	ASSEMBLY NO.	REV.
ESWB-0045	9V-M1201V	

STAGE NO	ASSY. NAME	SERIAL NO.
	Electro-static Workbench Assy.	Qualification UNIT

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2V31

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
Qual 9V-M1201V 12	10-8-70	1	9V-M1201V	Qual. Test Spec. Paragraph	E02			[illegible]
1	R.D.	1	ESWB Qual. Unit	3.1V.3 b Requires that the	DE			11-13-70
				chamber pressure be Reduced				
				To 10^{-4} mm of mercury and				
				be maintained for a minimum				
				of 6 hr.				
				This pressure was unable To				
				be obtained. A pressure				
				of 14×10^{-3} mm Hg was obtained				
			NASA PM-MA	QPA Concurs in Squawk [signature] 10/14/70				
				A LOW PRESS. SOAK OF 16×10^{-3} TO 14×10^{-3} mm Hg.				
				WAS MAINTAINED FOR 8 HRS.				
				RECOMM. DISPOS: USE AS IS	[signature] 11-13-70			
				Concur with CCSD disposition [signature] 11/13/70				

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616-61460
REV APR 66

INSPECTION SQUAWK SHEET

Qual Unit

SHEET 1 OF 6

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

SPACE DIVISION CHRYSLER CORPORATION

NO.	ASSEMBLY NO.	REV.
ESWB-0046	95M12015	
STAGE NO	ASSY. NAME: Electrostatic Workbench Assy	SERIAL NO.: Qualification unit

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2531

OPER. ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
QCI 95M12015 20+22	10-13-70	1	95M12015	Ref. QCI 95M12015 Items 20	E54			CCSD W-P 64 11-13-70
1	R.J.	1	ESWB Qual. unit	+ 22. Vehicle Dynamics Criteria	DE			
				for The Flight Axis require The				
				shield, power supply and Table				
				Top undergo test from "3 To 7 Hz				
				@ 0.43 inches D.A. displacement."				
				Actual - Vibration Table is only				
				capable of performing Test				
				at 5 To 7 Hz @ 0.43 inches				
				D.A. displacement.				
			NASA PM-MA-QPA	Concurs in Squawk	[signature]		11/4/70	
				Recomm. Dispos.: Use As Is	P. [signature]	11-13-70		
				Concur with CCSD disposition	J.B. Rendall		11/13/70	

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SPACE DIVISION **CHRYSLER** CORPORATION

SHEET 2 OF 6

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

NO.	ASSEMBLY NO.	REV.
ESWB-0046	95M12015	
STAGE NO	ASSY. NAME: Electrostatic Workbench Assy.	SERIAL NO.: Qualification UNIT

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
QCI 95M12015 21	10-13-70	1	95M12015	Ref. QCI 95M12015 ITem 21	V12			CCSD 111-P 64 10-13-70
2	R.A.	1	ESWB-Qual UNIT	During Visual inspection (after Dynamic Test in Flight Axis) iT was noted That The bond between The Ion Shield And The connecting block has become weakened.	DE			
			NASA PM&MA&PA	Concurs in Squawk [signature] 10/14/70				
				This weakening did not propagate during remainder of vibr. test & is therefore not important.				
				Recomm. Dispos. : USE AS IS [signature] 11-13-70				
				Concur with USE AS IS disposition (CCSD) J.B. Kendall 11/13/70				

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616-61480
REV APR 65

INSPECTION SQUAWK SHEET

Qual. Unit

SHEET 3 OF 6

[✓] SUPPLIED ITEM
[ ] R & D ITEM
[ ] GFE

SPACE DIVISION CHRYSLER CORPORATION

NO.	ASSEMBLY NO.	REV.
ESWB 0046	95M12015	

STAGE NO	ASSY. NAME	SERIAL NO.
	Electrostatic W/Board Assy	Qualification Unit

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION: DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL: DATE & INSPECTION STAMP
QCI 95M12015 24 Thru 32	R.H.	1	95M12015	Ref. QCI 95M12015 Item No.	E54			CCSD M-P 1-64
3	10-28-70	1	ESWB-Qual. UNIT	24 Thru 32.	DE			
				The Test equipment is not				
				capable of preforming The				
				Vehicle Dynamic Test-Lateral				
				Axes at the following Levels:				
				2.0 To 4.0 Hz @ 0.34 inches DA. displacement				
				4.0 To 7.0 Hz @ 0.28 g's peak				
				7.0 To 20 Hz @ 0.08 g peak				
				Concur with squawk				
				E J Peskek NASA PM-MA-QPR 10/28/70				
				Recomm. Dispo.: Use as is	P. Tholsted 11-13-70			
				Concur with CCSD disposition J.B. Rundall 11/13/70				

818-81450
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SHEET 4 OF 6

☑ SUPPLIED ITEM
☐ R & D ITEM
☐ GFE

SPACE DIVISION CHRYSLER CORPORATION

NO.	ASSEMBLY NO.	REV.
ESWB-0046	95M12015	
STAGE NO	ASSY. NAME: Electrostatic Workbench Assy	SERIAL NO.: Qualification Unit

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2531

OPER. / QC ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
95M12015 42	R.M.	1	95M12015	Ref. QCI 95M12015 Item #42	V12			
4	10-28-70	1	ESWB Qual. UNIT	The Knob on the storage	DE			11-13-70
				clamp twisted off when table				
				Top was being mounted for				
				vibration test. No. 42 Ref. QCI				
				CONCUR WITH SQUAWK				
				E J Pickett NASA PM MH SPA 10/28/70				
				Operator was not properly cautioned - dwg now covers with a warning.				
			REC.	DISPOS.: Replace pin.		J. Theobald 11-13-70		
				Concur with CCSD disposition		J. Brindall 11/13/70		

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual. Unit

SPACE DIVISION **CHRYSLER CORPORATION**

SHEET 5 OF 6

- [x] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

NO.	ASSEMBLY NO.	REV.
ESWB-0046	95M12015	
STAGE NO	ASSY. NAME: Electrostatic WK bench Assy	SERIAL NO.: Qualification unit
SHOP ORDER TOTAL QTY: 1 / SHOP ORDER NO.: / INSP. STA.: 41	NEXT ASSY. NO.	MFG. DEPT. FOUND: 2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
QCI 95M12015 35,37,40,	42,45,47 R.M.	1	95M12015	Ref. QCI 95M12015 Item No.	E54			
5	10-28-70	1	ESWB Qual. UNIT	35, 37, 40, 42, 45, and 47	DE			11-13-70
				The Test equipment is not				
				capable of preforming at				
				20 To 100 Hz @ 0.0020 inches D.A. displacement				
				as called out for Test 3.15.4.2				
				Sinusoidal Evaluation Criteria				
				of spec.				
				Concur with squawk				
				P J Pratak NASA PM-MB-QPH 10/28/70				
				Recomm. Dispos.: USE AS IS	P. [illegible] 11-13-70			
				Concur with CCSD disposition J B Rudall 11/13/70				

616-61480
REV APR 66

INSPECTION SQUAWK SHEET

Qual UNIT

SPACE DIVISION **CHRYSLER CORPORATION**

SHEET 6 OF 6

- [✓] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

NO.	ASSEMBLY NO.	REV.
ESUB-C046	9VM12015	

STAGE NO	ASSY. NAME	SERIAL NO.
	Electrostatic wkbench Assy	Qualification unit

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2531

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
QCI 9VM12015 56	10-29-70	1	9VM12015	Ref. QCI 9VM12015 Item No.	V12			CCSD M-61
6	R. M.	1	ESUB-Qual Unit	56.	DE			11-13-70
				Visual inspection of The shield				
				and power supply after The				
				Lift-off Random Test-Tangential				
				Axis - The mating connection				
				between The fiberglass pole and				
				The block on The rear of The				
				shield has become weakened				
				enabling The shield To be				
				Twisted slightly.				
				Concur with squawk				
				S/ [illegible] NASA [illegible] 70				
				This could be expected after vibration - no				
				failure involved - most of movement is due				
				to flexibility of TFE.				
				RECOMM. ACTION: USE AS IS		PJ [illegible] 11-13-70		
				Concur with CCSD disposition		JB Kincaid 11/13/70		

616-61480
REV APR 65

INSPECTION SQUAWK SHEET

Qual. Unit

SPACE DIVISION **CHRYSLER** CORPORATION

SHEET 1 OF 1

- [✓] SUPPLIED ITEM
- [ ] R & D ITEM
- [ ] GFE

NO.	ASSEMBLY NO.	REV.
ESWR-0072	9V MI 2015	
STAGE NO	ASSY. NAME: Electrostatic wkbench Assy	SERIAL NO.: Qualification Unit

SHOP ORDER TOTAL QTY	SHOP ORDER NO.	INSP. STA.	NEXT ASSY. NO.	MFG. DEPT. FOUND
1		41		2V31

OPER. / ITEM	ORIGINAL DATE & INITIAL	QTY. UNIT / DEF.	DEFECTIVE PART NUMBER, S/N / LOCATION	DESCRIPTION: (DEFECTIVE PART NAME, DISCREPANCY, CONDITION, ETC.)	DISPOSITION: DEF. CODE / RESP. CODE	RECOMM. ACTION / CORRECTED BY	QTY. ACCEPT / QTY REJECT	FINAL DATE & INSPECTION STAMP
QC/9V MI2015 78	10-30-70	1	9V MI2015	The data findings during	E03			CCSD M-P 64
1	R.H.	1	ESWB-Qual. UNIT	functional Test No 78-2 and	DE			11-13-70
				78-3 per QCI 9V MI2015 indicates				
				The pull acquired for positions				
				4, 3, 2, and 1 of switch S2				
				were found to be (0) zero.				
				Concur with squawk				
				E J Peselik NASA PM-MA-QTA 11/3/70				
				At this time there appears to be at least two problems				
				preventing compliance with Appendix I para. 3.3.2:				
				1. Insufficient ions are reaching the test disk.				
				2. Method of attachment to the test disk in the				
				Force Test Fixture has a major influence on the				
				apparent forces present.				
				Satisfactory solutions to these problems are not				
				presently available. REF: ESWB0030, 0033, 0039, 0040, 0041, & 0042				
				RECOMM. DISPOSITION: ACCEPT AS IS				
				P Tracked 11-13-70				
				Concur with CCSD Statement relative to insufficient pull,				
				acceptance is made due to unavailability of sufficient				
				funds and time for further investigation of this				
				problem. J B Rendall S&E-ME-MX 11/13/70				

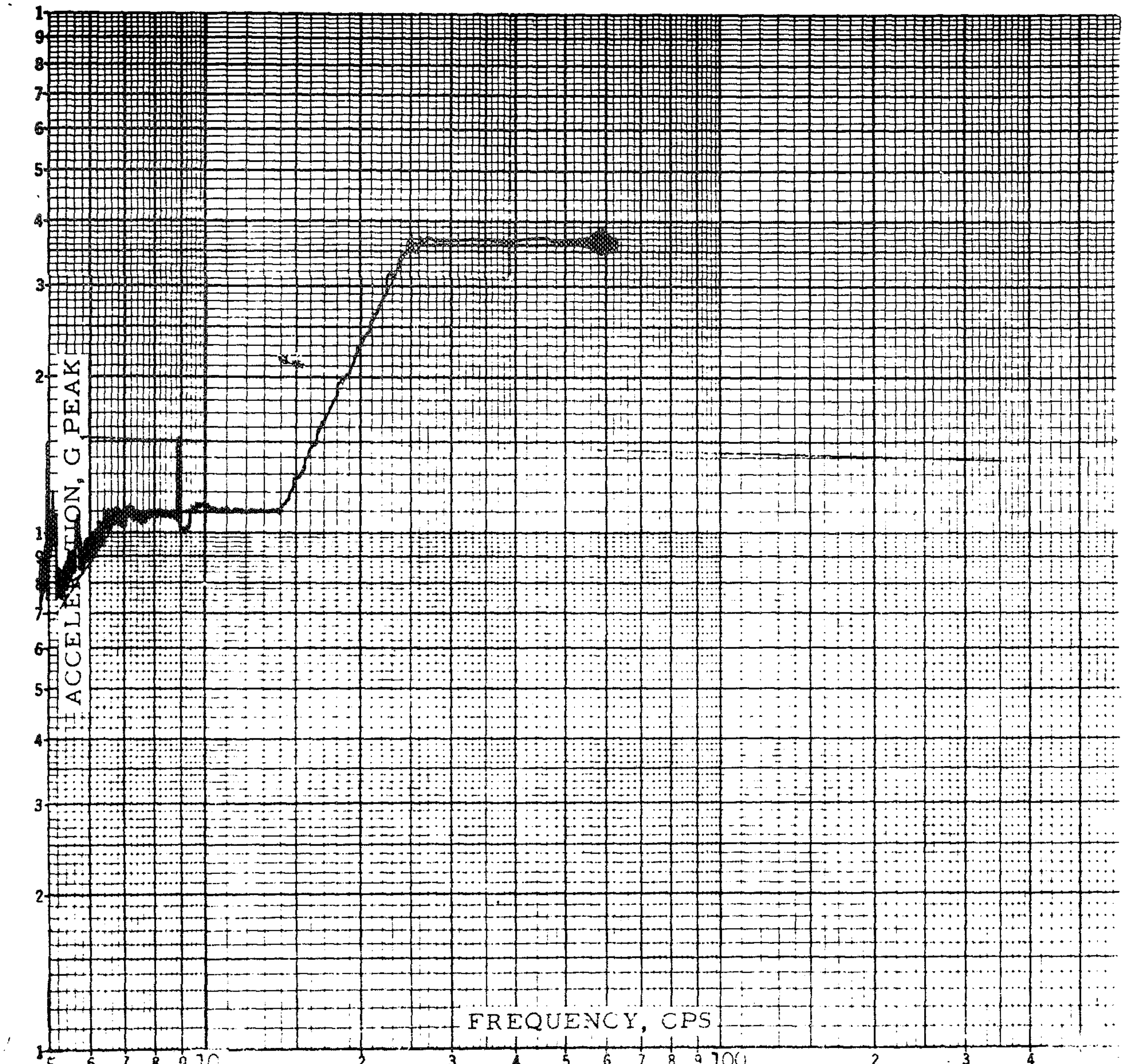
APPENDIX F

VIBRATION PLOTS

FOR THE

ELECTROSTATIC GRAVITY SUBSTITUTE WORKBENCH

(QUALIFICATION TEST)



Ref: QC1 #20

VIBRATION PLOT

SINUSOIDAL

Test Item: ________

Serial No. ________

Part No. ________

Sample No. Qual Unit

Axis: ________

Accelerometer No. ________

Filtered: ________

Location: ________

Sweep: ________

Rate: ~~1~~ Octave/Minute

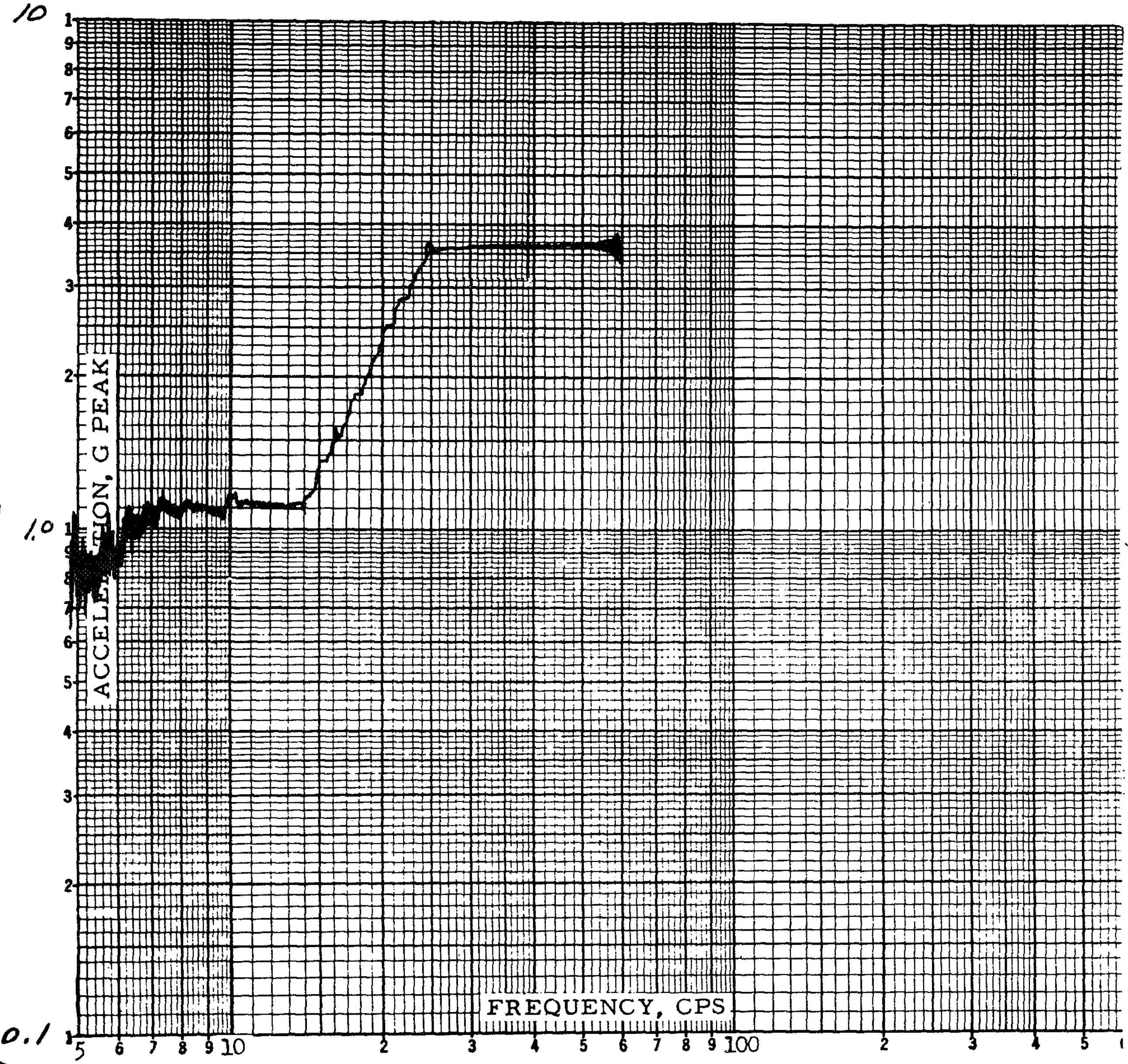
Level: ________

Date: ________

Remarks:

Witnessed by
Eugene L McPherson
A.C. Stevens

NASA-MSFC-MAF



Vehicle Dynamics
Ref: QC1 #22

VIBRATION PLOT

SINUSOIDAL

Test Item: Elect. Work Bench

Serial No. Table Top

Part No. ______

Sample No. QUALIFICATION UNIT

Axis: flight

Accelerometer No. 1

Filtered: ______

Location: ______

Sweep: ______

Rate: ~~1.7~~ 3.0 Octave/Minute

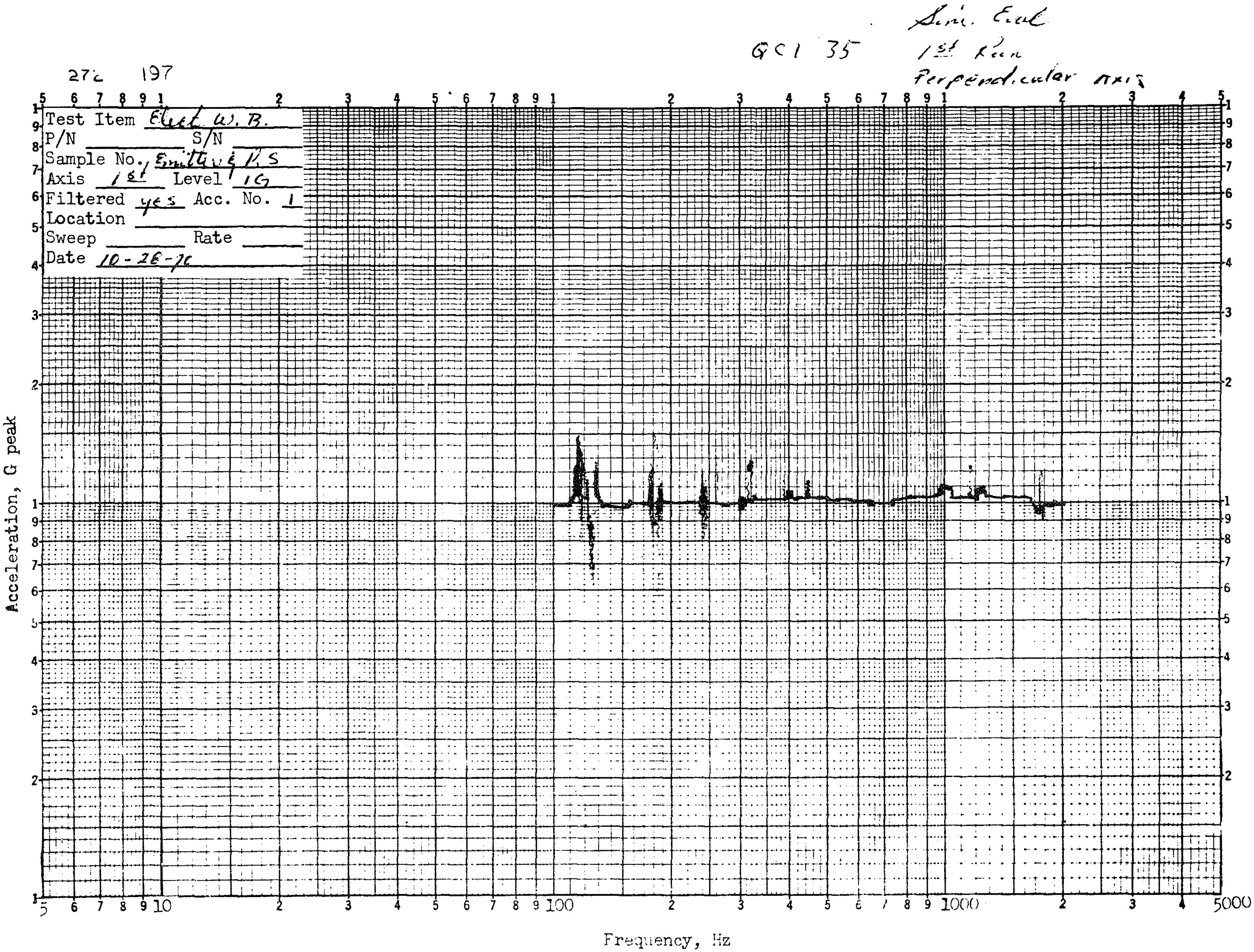
Level: Shape

Date: 10-13-70

Remarks:

Witnessed by:
A.C. Stevens
Eugene L McPherson

NASA-MSFC-MAF

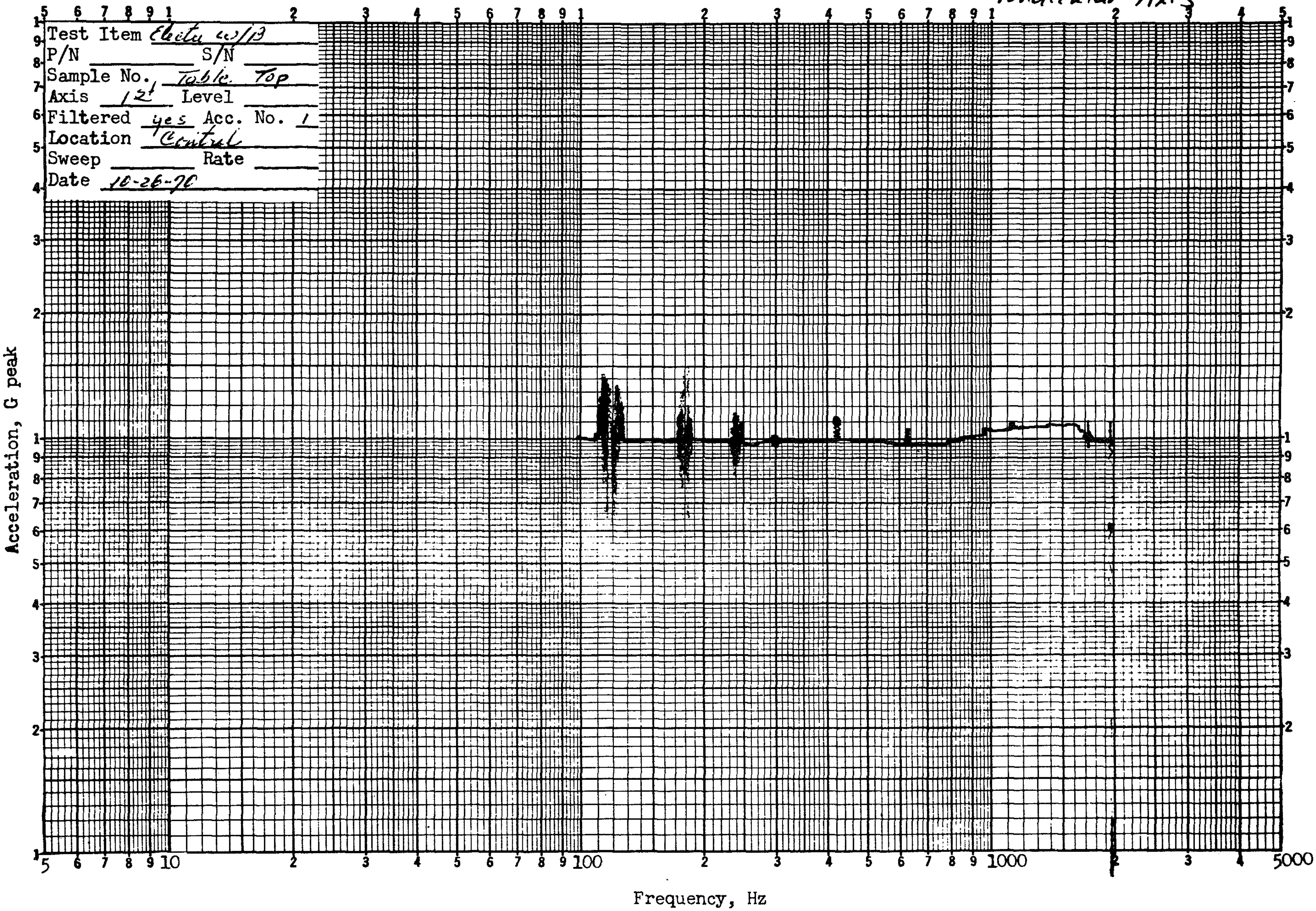

Sini. Eval
GCI 35
1st Run
Perpendicular Axis
272 197
Test Item Elect W. B.
P/N
S/N
Sample No. Emitting R. S
Axis 1st Level 1G
Filtered yes Acc. No. 1
Location
Sweep
Rate
Date 10-26-70
Acceleration, G peak
Frequency, Hz
5 6 7 8 9 10 2 3 4 5 6 7 8 9 100 2 3 4 5 6 7 8 9 1000 2 3 4 5000

27 197

QC1 37

Sine Eval.
2nd Run
Perpendicular Axis

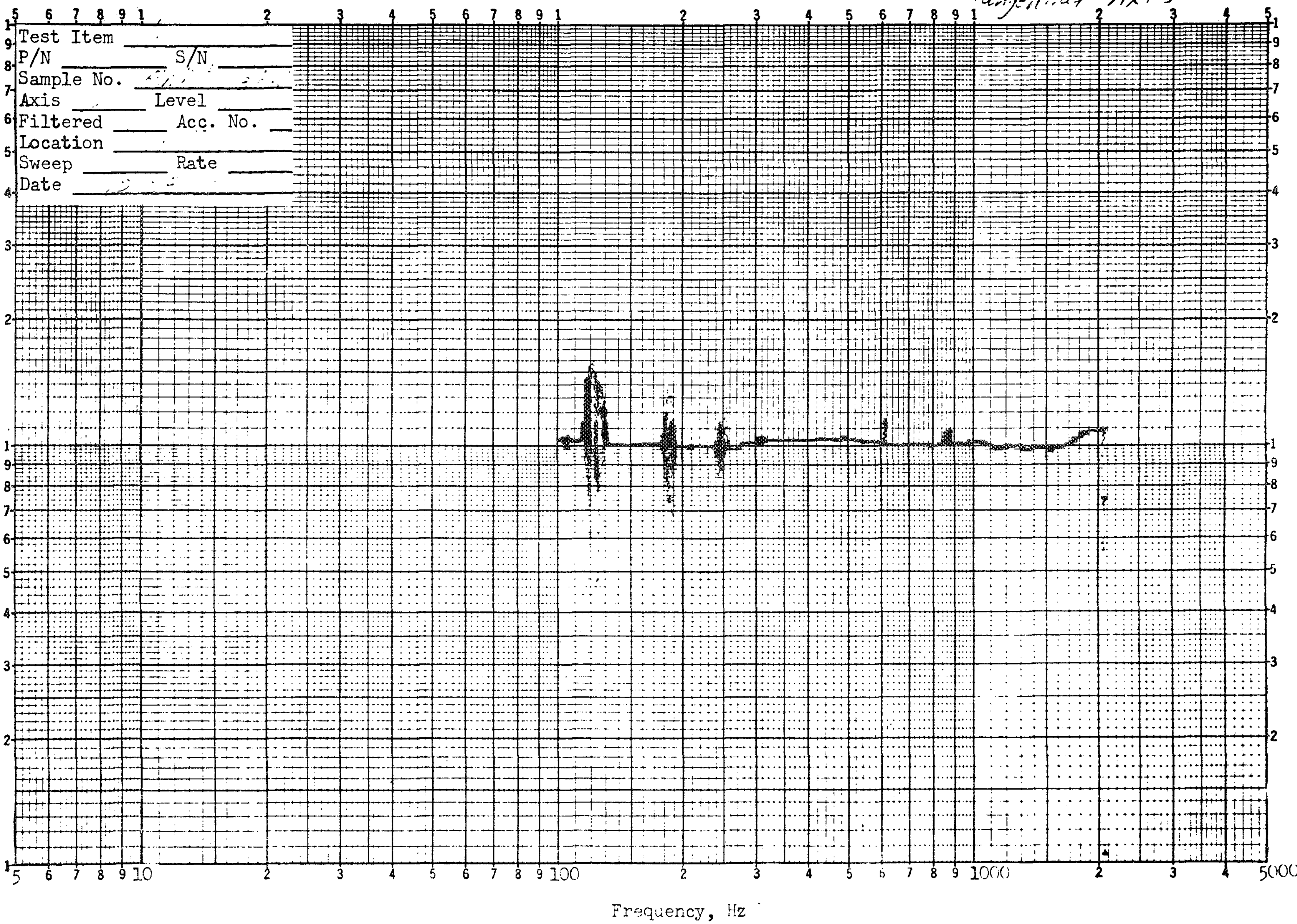
Test Item Electr w/B
P/N S/N
Sample No. Table Top
Axis 12' Level
Filtered yes Acc. No. 1
Location Central
Sweep Rate
Date 10-26-70



2720 197

QC140

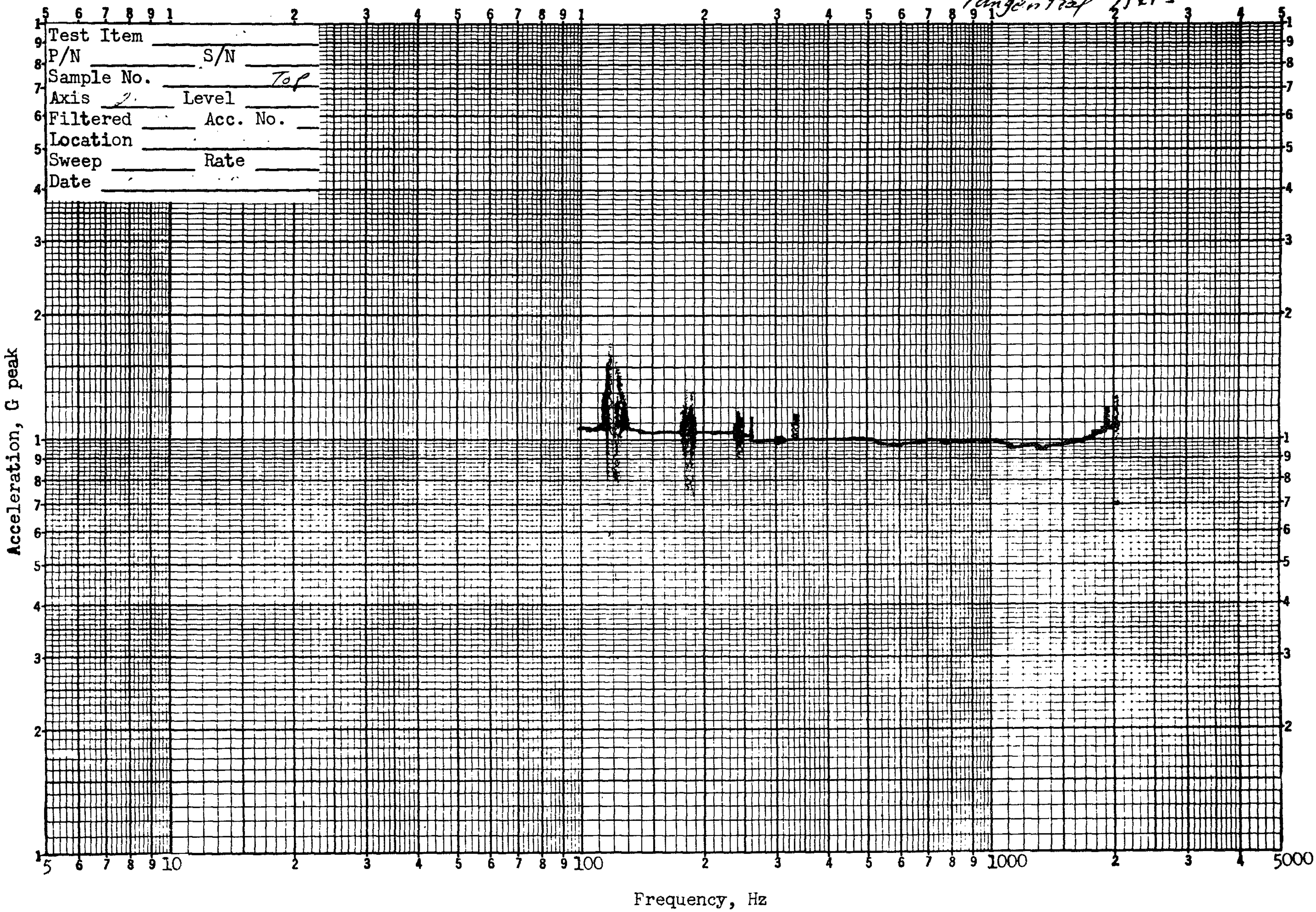
Tangential Axis



272 197

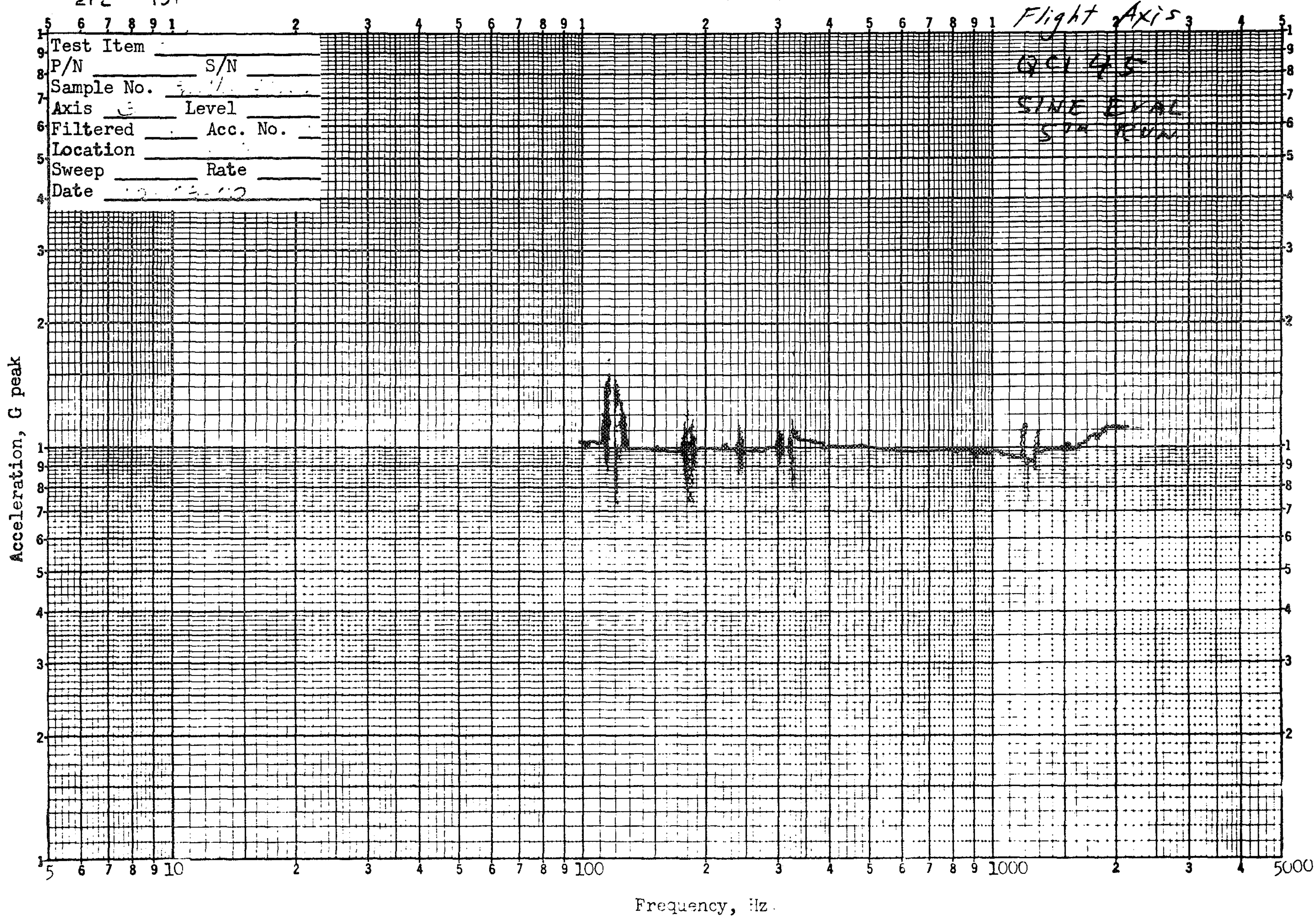
QC1 42

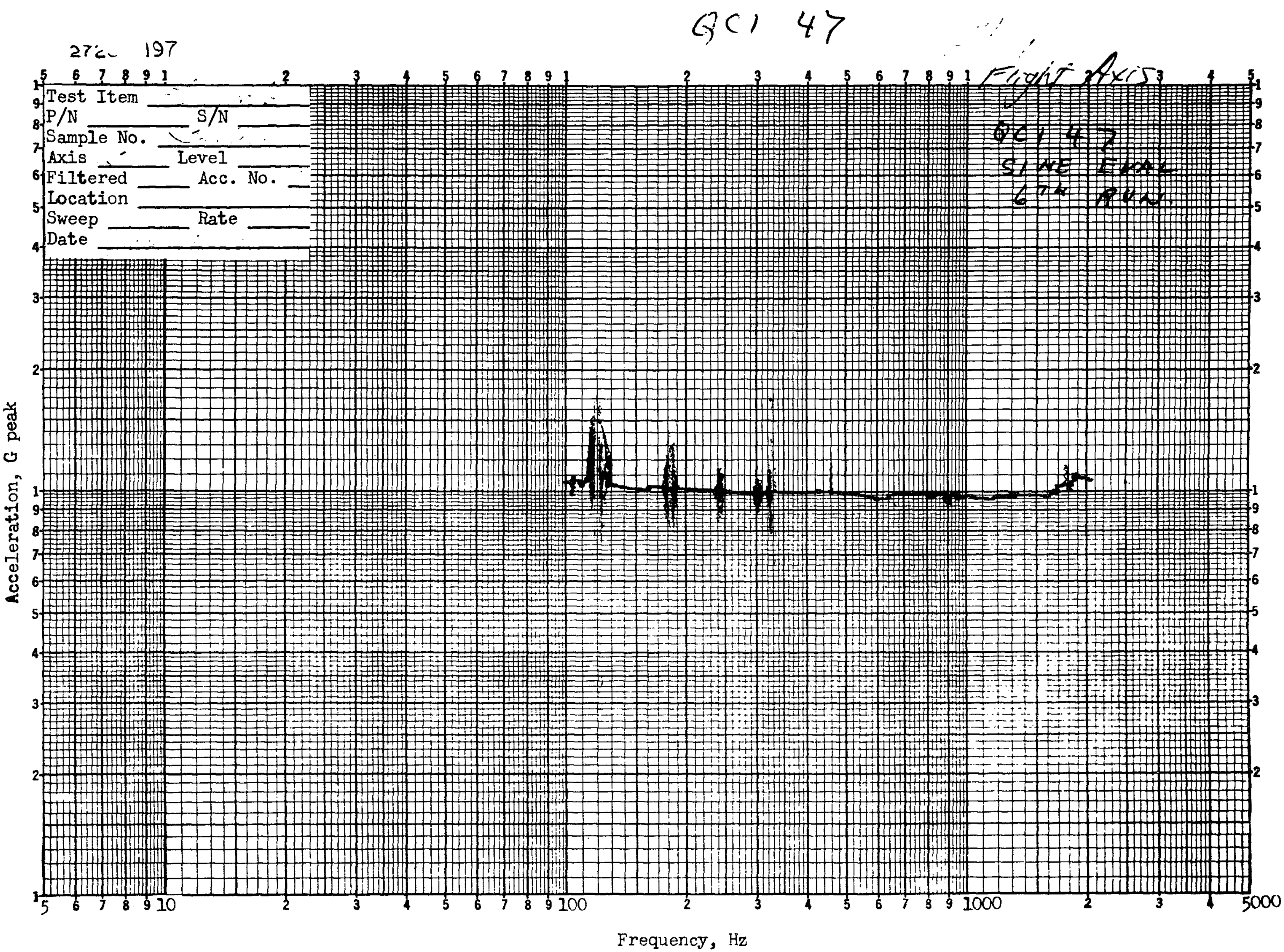
Tangential Axis



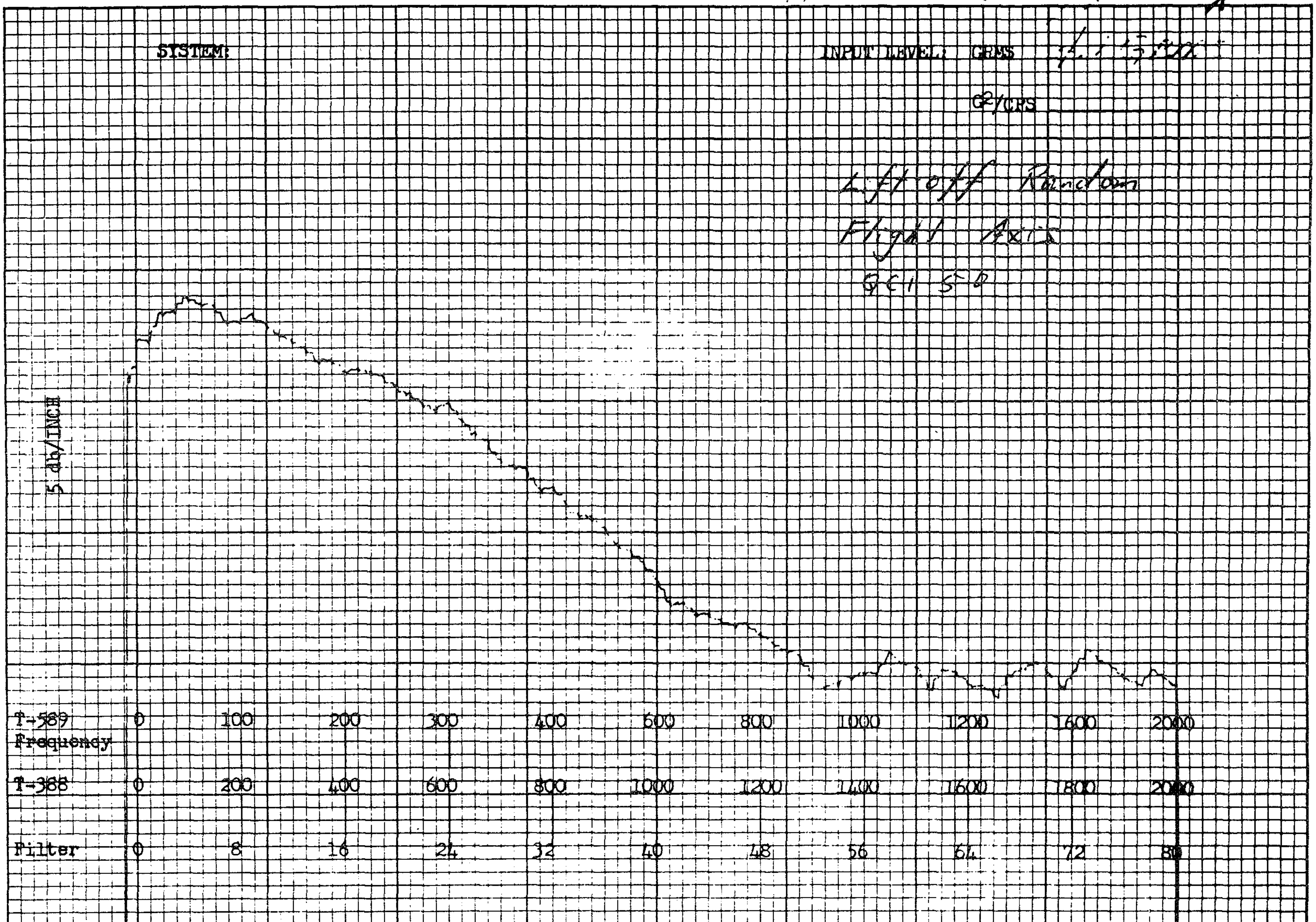
27c 197

QC1 45

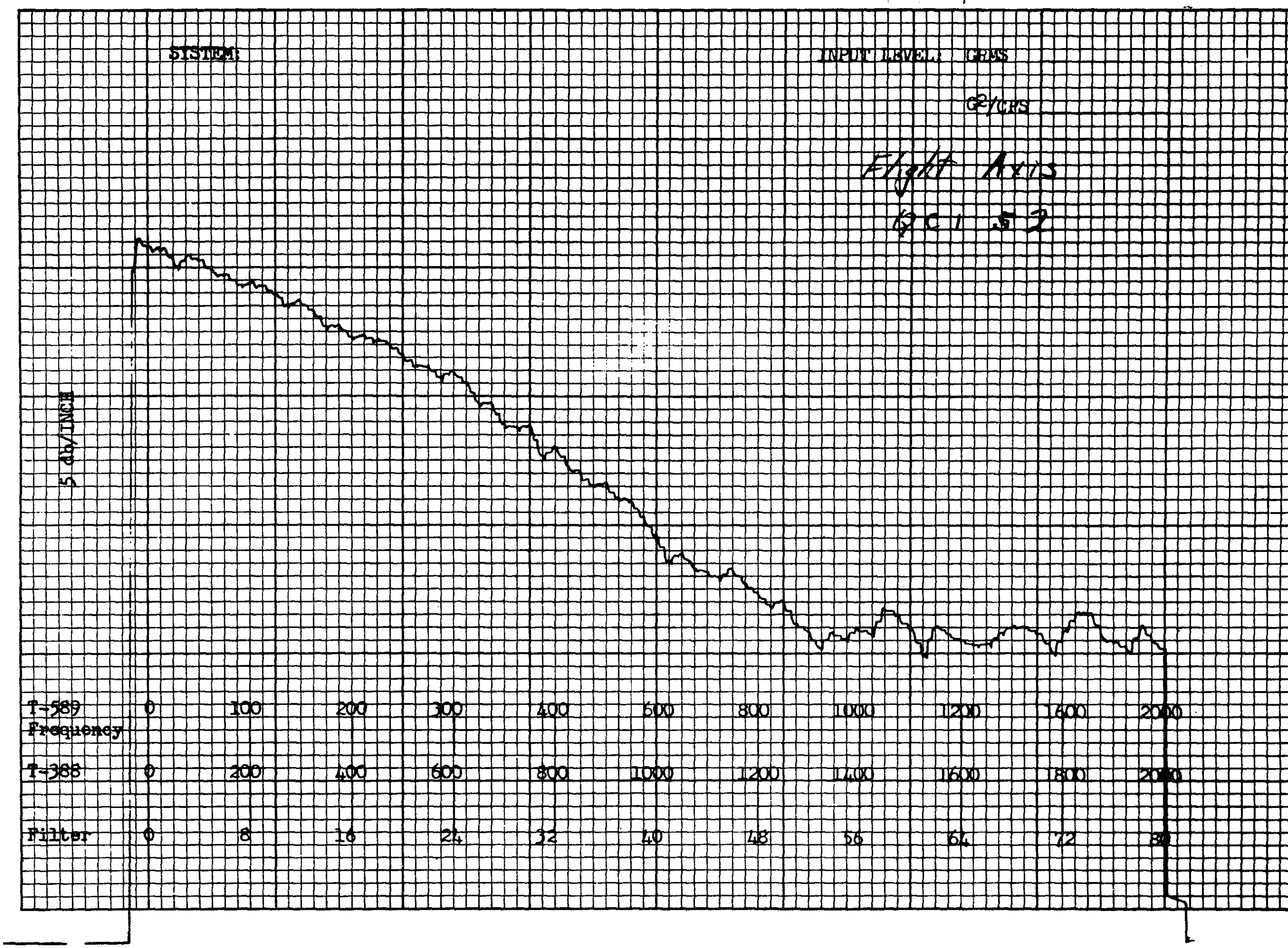



QCI 47
272. 197
Flight Axis
QCI 47
SINE EVAL
6TH RUN
Test Item
P/N
S/N
Sample No.
Axis
Level
Filtered
Acc. No.
Location
Sweep
Rate
Date
Acceleration, G peak
Frequency, Hz
10
100
1000
5000

84-272 -Nov. 65 GCI 50

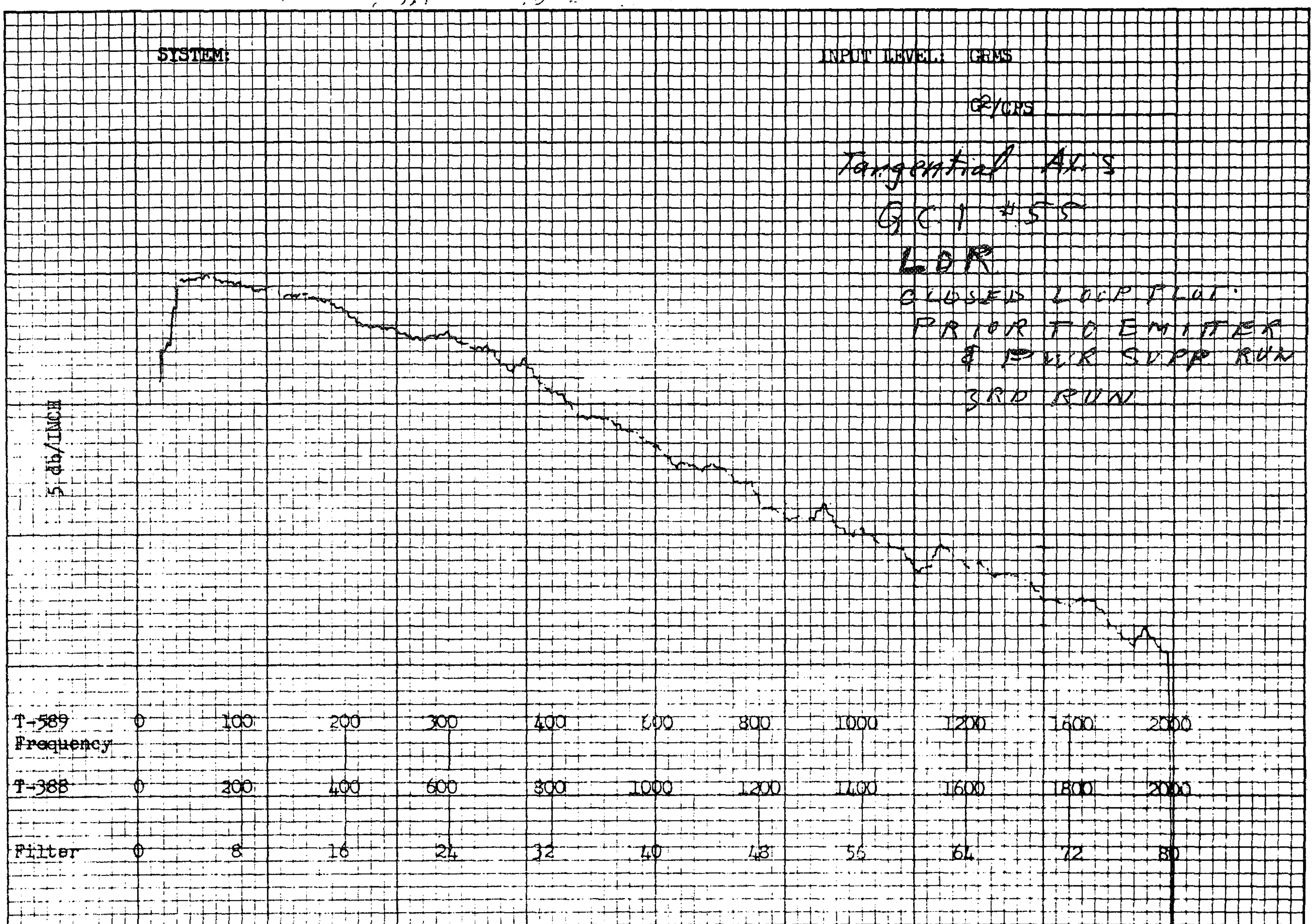


84-272 ⌐-Nov. 65 GCI 52

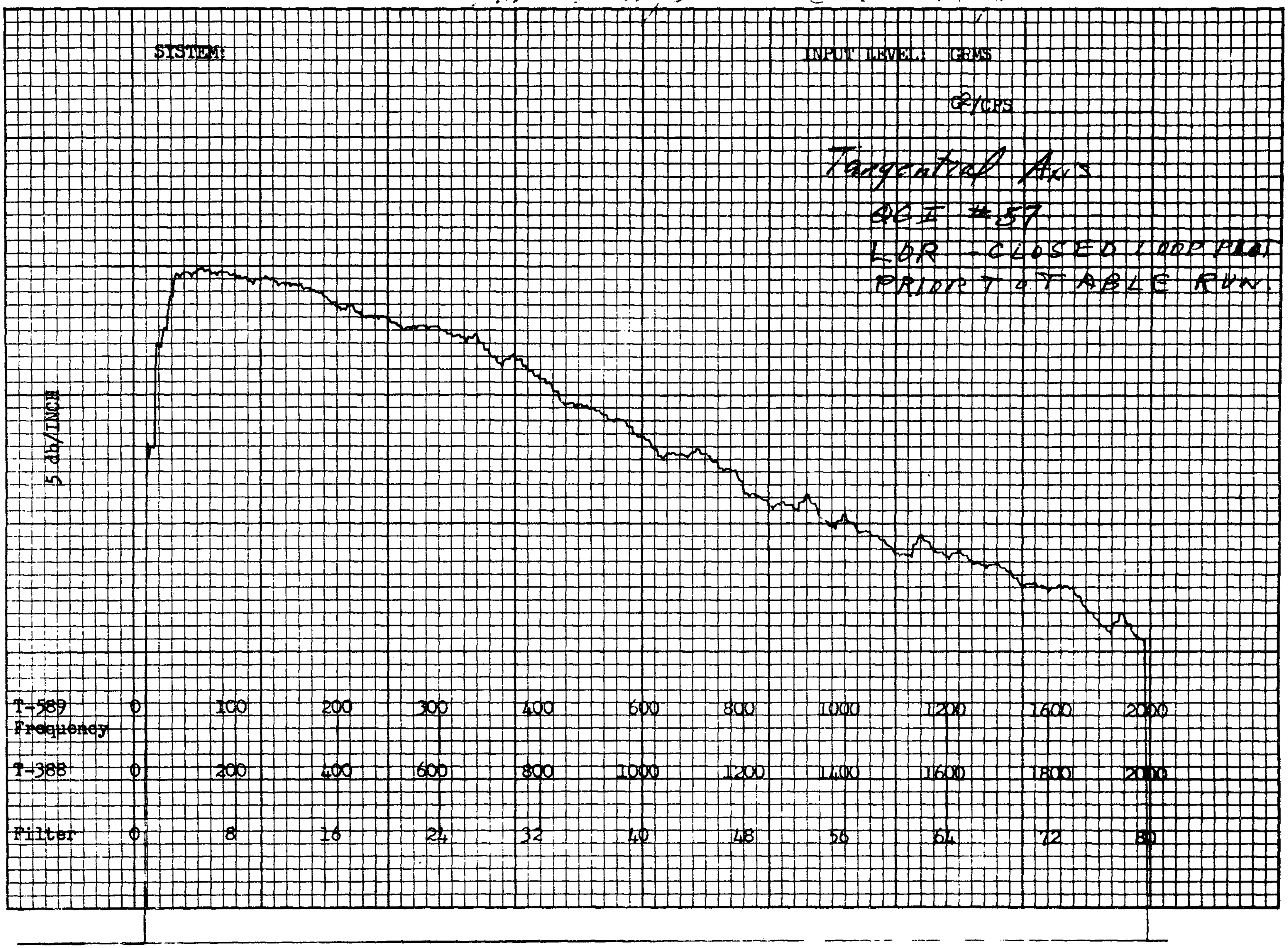


GCI #55

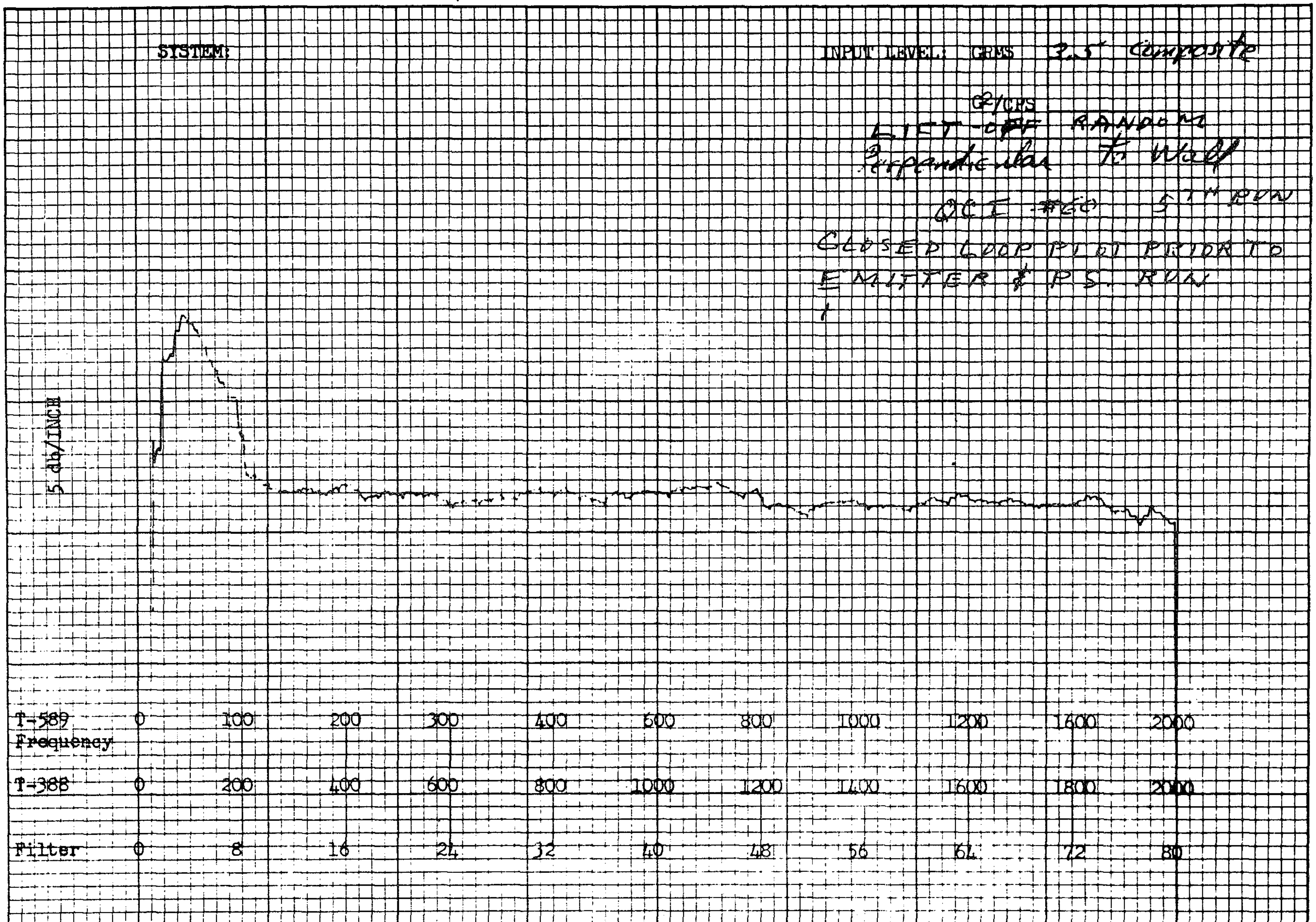
84-272 J-Nov. 65



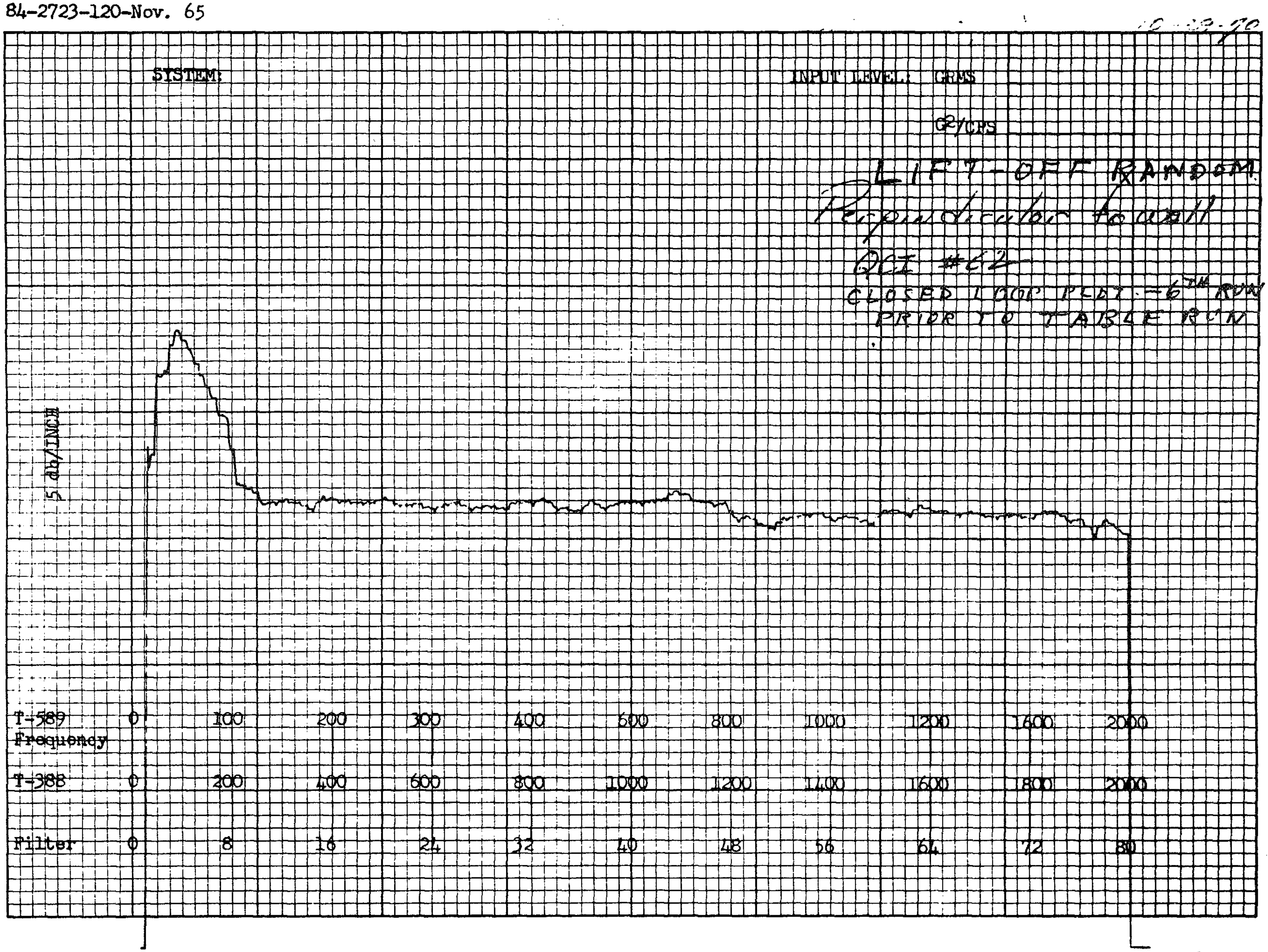
84-272 .)-Nov. 65



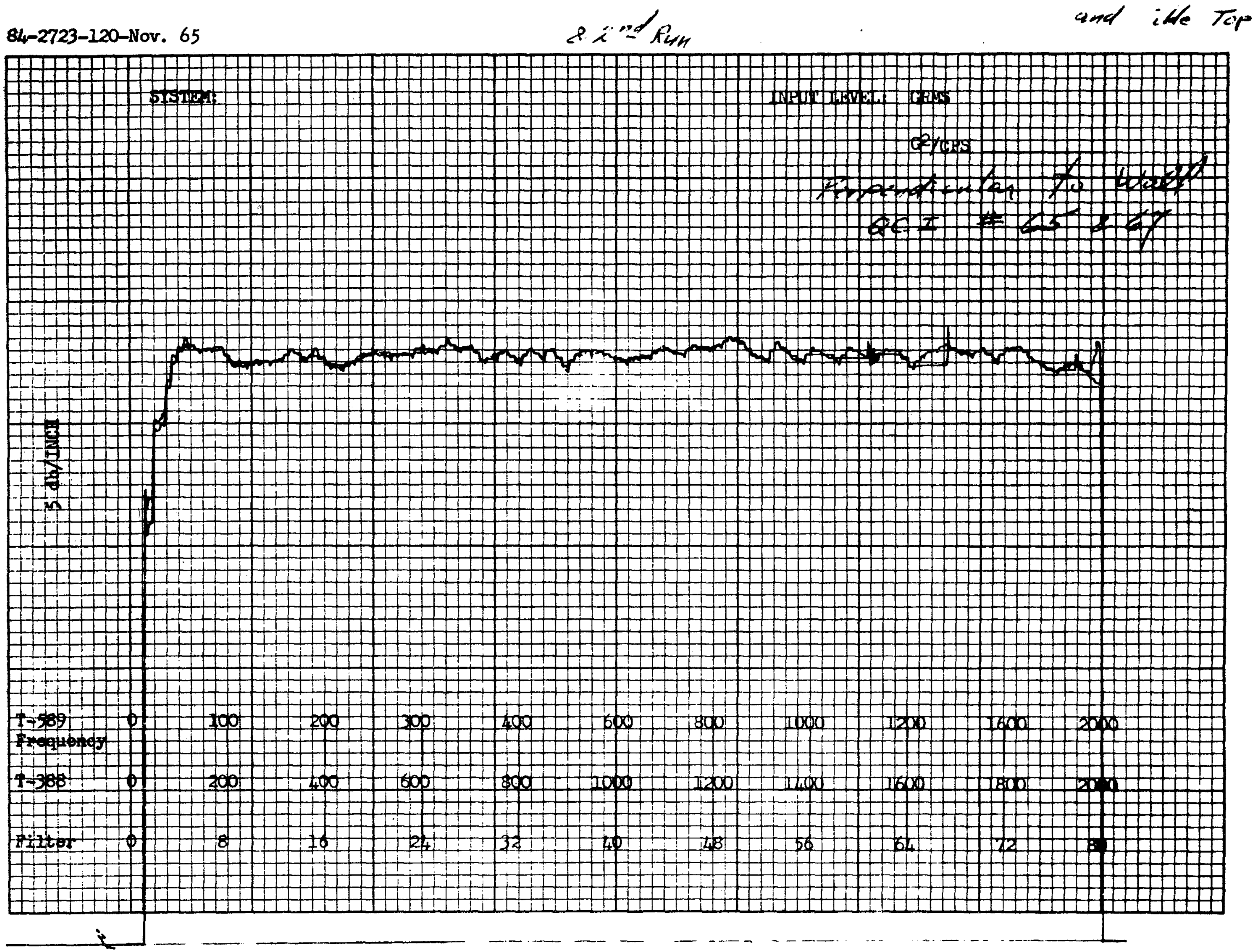
SYSTEM:
INPUT LEVEL: GRMS
G²/CPS
Tangential Axis
QCI #57
LBR - CLOSED LOOP PLOT
PRIOR TO TABLE RUN
5 db/INCH
T-589 Frequency 0 100 200 300 400 600 800 1000 1200 1600 2000
T-388 0 200 400 600 800 1000 1200 1400 1600 1800 2000
Filter 0 8 16 24 32 40 48 56 64 72 80


SYSTEM:
INPUT LEVEL: GRMS 3.5 composite
G²/CPS
LIFT-OFF RANDOM
Perpendicular to Wall
QCI #60 5TH RUN
CLOSED LOOP PILOT PRIOR TO
EMITTER & PS. RUN
5 db/INCH
T-589 Frequency 0 100 200 300 400 600 800 1000 1200 1600 2000
T-388 0 200 400 600 800 1000 1200 1400 1600 1800 2000
Filter 0 8 16 24 32 40 48 56 64 72 80

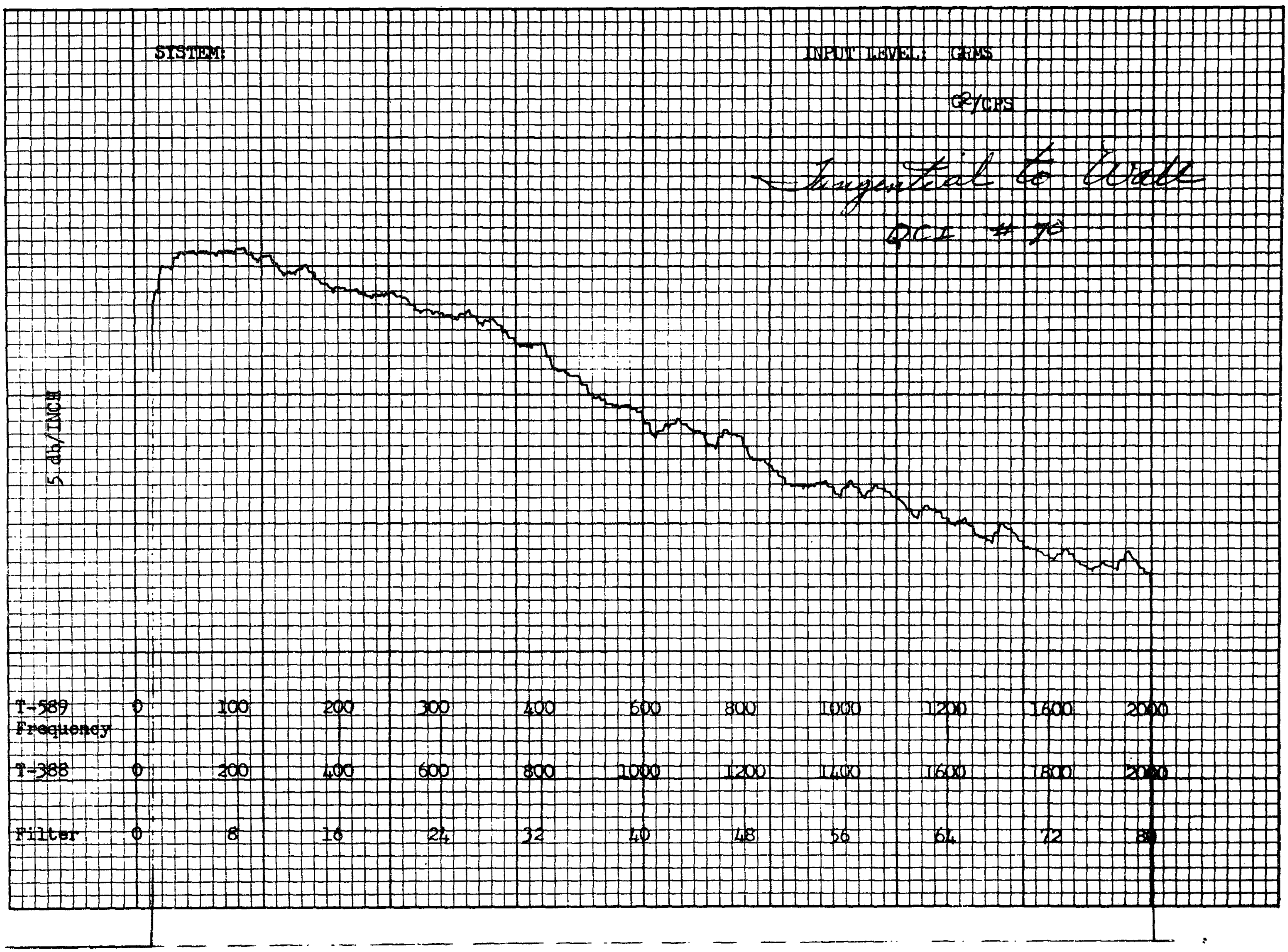
84-2723-120-Nov. 65



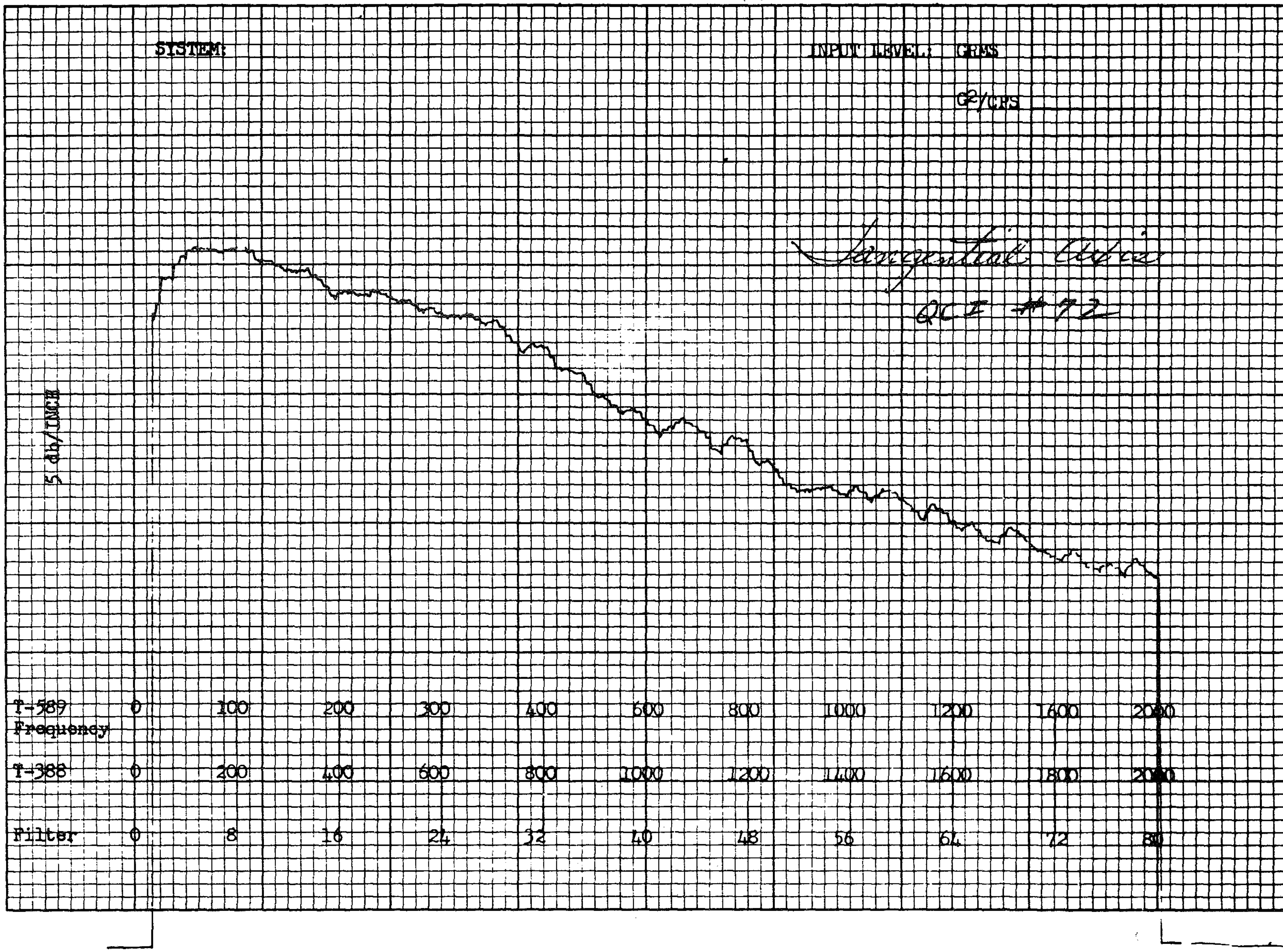
84-2723-120-Nov. 65



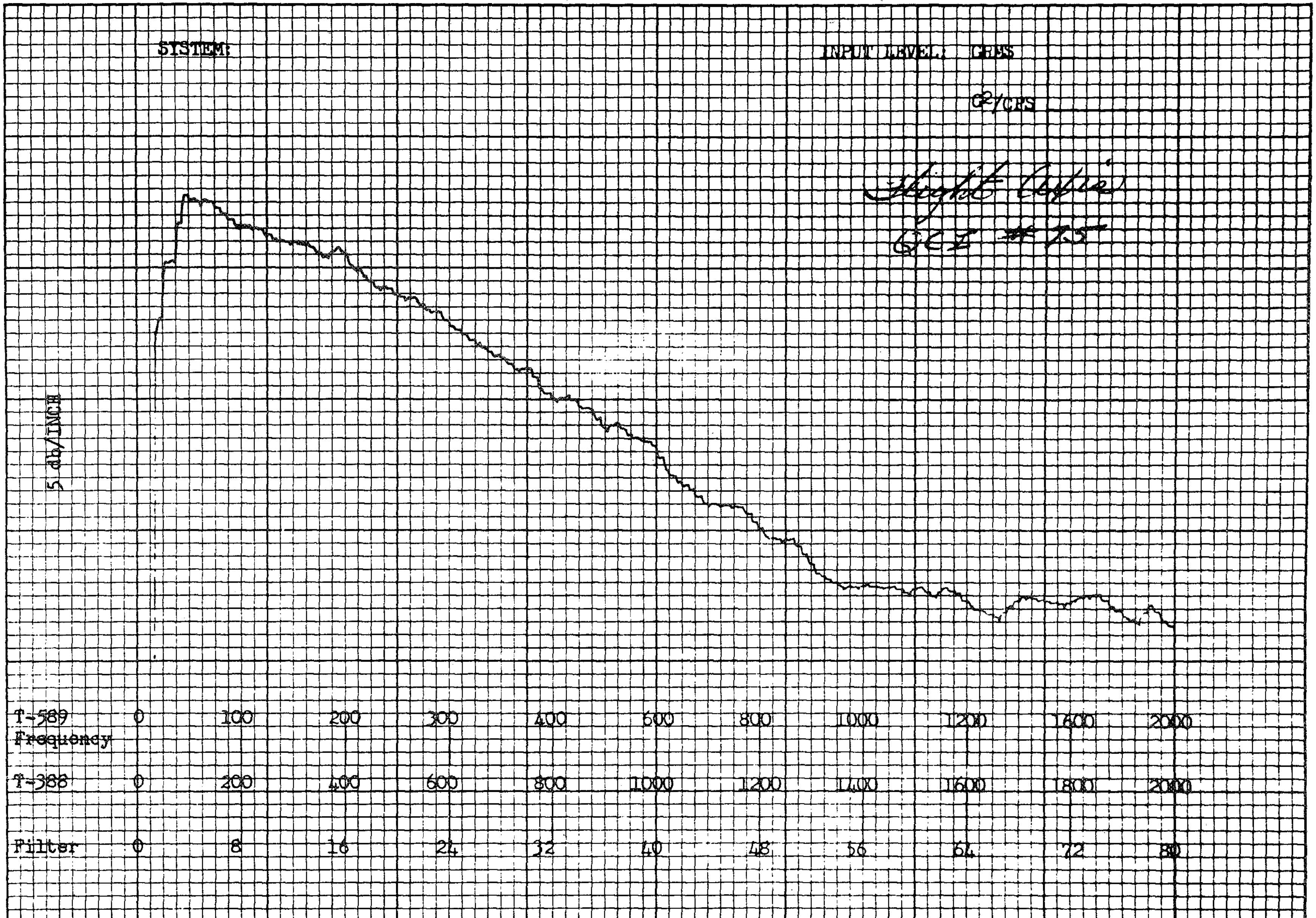
84-2723-120-Nov. 65



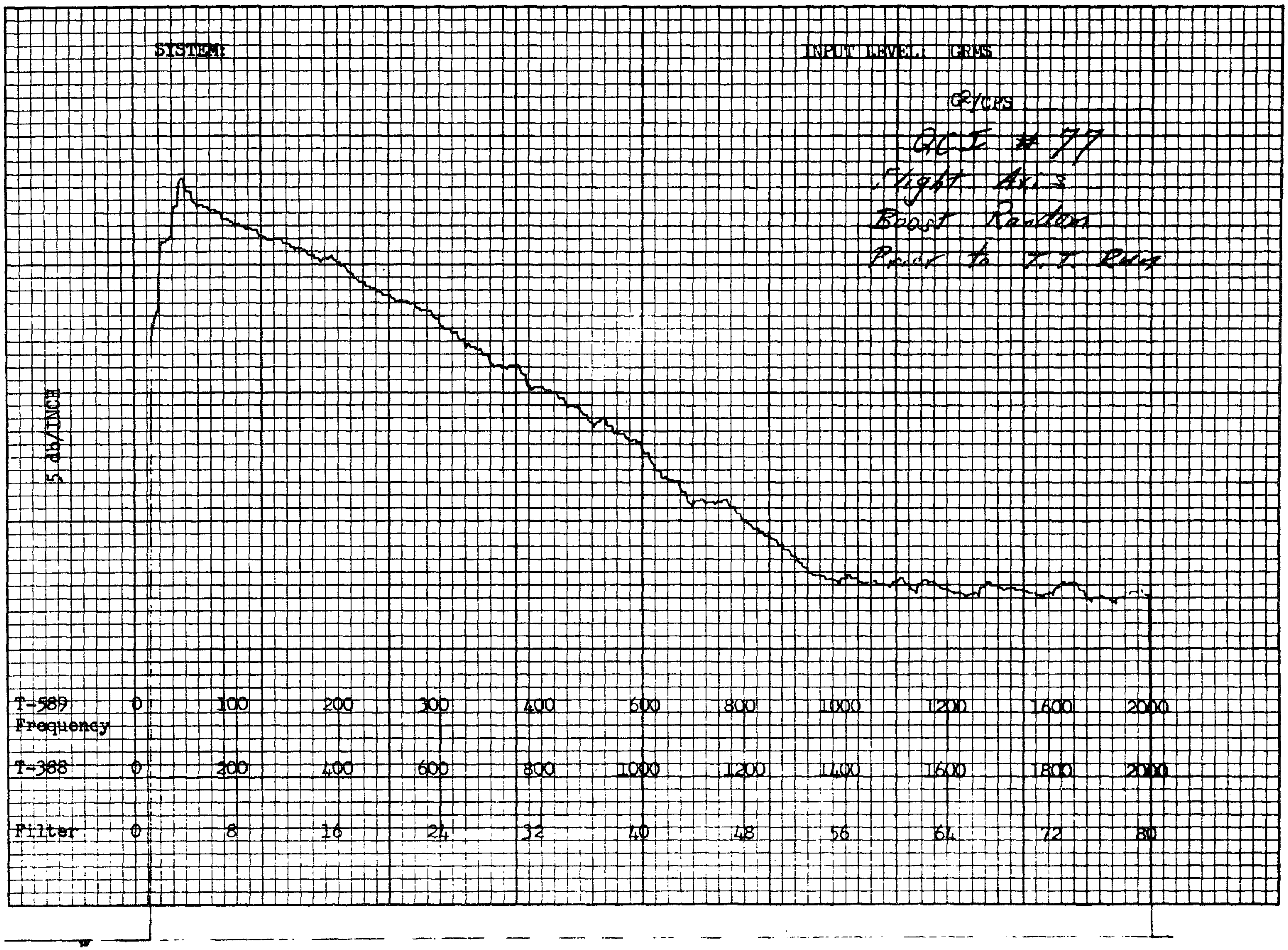
84-2723-120-Nov. 65



84-2723-120-Nov. 65



84-2723-120-Nov. 65



APPENDIX G

QUALIFICATION TEST LOG

QUALIFICATION TEST LOG

LAB Form 2A / LIFE HISTORY

	ALLOWABLE OPERATING TIME
	CALENDAR LIFE

LOCATION	EVENT NO.	EVENT SUBJECT	DATE 1970	SUMMARY OF CHRONOLOGICAL EVENTS (TEST DOCUMENT NUMBER / TEST DESCRIPTION / NATURE & DESCRIPTION OF MALFUNCTIONS / SERIAL NUMBER OF REMOVED OR REPLACED PARTS / MODIFICATIONS / ADJUSTMENTS / REPAIRS / MAINTENANCE / SHIPPED / RECEIVED / ENVIRON. / ETC)	RUNNING TIME/OTHER (HOURS AND MINUTES) START	STOP	TOTAL TIME	CUM TOTAL	STAMP OR INITIAL
LAB 212	1	VISUAL	8/26						
212	2A	FUNCTIONAL	8/26	PER ¶ 3.3.1 & 1/2 3.3.2 APPEND. I; NO FORCE W/TABLE ROTATED (.003)					
201	2B	FUNCT.	8/27	PER ¶ 3.3.2 APP. I; FORCE ACCEPTABLE					
201	3B	EMI	8/27-28	PER APPEND. II; RADIATED PEAKS HIGH - SQUAWK 0028 OPEN					
REL. TEST	3A	ENG. TEST	9/1	ON BENCH - NO FORCES DEVELOPED (ENG. NOTEBOOK 826 pg 53)					
LAB 212	3B	DIAGNOST.	9/2-4	ALL SYST. RECKD. - STILL NO FORCE; COMBINATIONS WITH PROTOTYPE					
				TESTED - BOTH QUAL. TABLE & P/S APPEAR MARGINAL, ION BLEED					
				NOT OPTIMUM (ENG. NOTEBK 826 pg. 54-60)					
REL. TEST	3C	ENG. TEST	9/4-10	BENCH EXPER. W/ANODIZE SAMPLES INCONCLUSIVE; NEW					
				BLEED COVER ON QUAL. UNIT P/S & PROTO TABLE LOOKS GOOD -					
				TABLE #1 SHOWS ONLY 66 GRAMS (ENG. NOTEBK 826 pg 61-67)					
MFG			9/10-11	CEMENT NEW BLEED COVER (95M12016 REV. D), UPDATE					
				PROTO TABLE TO QUAL. CONFIG.					
LAB 201	2C	FUNCT.	9/14	RERAN PER ¶ 3.3.2 APP. I - PASSED					
201	3D	EMI	9/14	RERAN RADIATED TEST PER APP. II ¶ 6.2 - SOME FREQ.					
				STILL ABOVE SPEC. LIMIT					
REL TEST	3E	ENG. TEST	9/15	FAILED TO ATTAIN MIN. AVG. FORCES ON BENCH; UNIDENTIFIED					
				LOCAL ENVIRON. FACTORS MAY BE CAUSE.					
REL TEST	4	FUNCT.	9/16	INSTALLED IN TEMPERATURE CHAMBER, RUN PER ¶ 3.3.1 & 3.3.2					
				APP. I - PASSED					
REL TEST	4A	ENG. TEST	9/16	ABBREV. TESTS ON 3 OTHER TABLES - ACCEPT. FORCES (E.NB 826 pg 69,70)					
REL TEST	5	LOW TEMP	9/17	COOL-DOWN BEGAN AT 8:15 AM; -50°F SOAK AT 9:30 AM					
			9/21	TERMINATED SOAK AT 8:15 AM; WARM-UP TO AMBIENT; DOOR OPENED 1:20 PM					
			9/21	NASA GREEN TAG #04993 ISSUED IN AM					
			9/21	SQUAWKS WRITTEN TODAY: #0033 AGAINST EVENT 2A					
			9/22	& #0034 AGAINST EVENT 3D.					
			9/25	TAG REMOVED; PAPER STRAIGHTENED OUT AT 2pm; FUNCTIONAL TEST					
	6	FUNCT.		SETUP REACTIVATED. ¶ 3.3.1 & PART OF ¶ 3.3.2 COMPL.					

QUALIFICATION TEST LOG

LH Form 2A / LIFE HISTORY

ALLOWABLE OPERATING TIME

CALENDAR LIFE

LOCATION	EVENT NO.	EVENT SUBJECT	DATE	SUMMARY OF CHRONOLOGICAL EVENTS (TEST DOCUMENT NUMBER / TEST DESCRIPTION / NATURE & DESCRIPTION OF MALFUNCTIONS / SERIAL NUMBER OF REMOVED OR REPLACED PARTS / MODIFICATIONS / ADJUSTMENTS / REPAIRS / MAINTENANCE / SHIPPED / RECEIVED / ENVIRON. / ETC)	RUNNING TIME/OTHER (HOURS AND MINUTES) START	STOP	TOTAL TIME	CUM TOTAL	STAMP OR INITIAL
REL TEST	6	FUNCT.	9/28	¶ 3.3.2 COMPL. AT 1100AM; HEAT ~~COLD~~ CHAMBER R.H. CONTROL OFF					
" "	7	HOT SOAK	9/28	CHAMBER UP TO +160° AT 3:15PM					
			9/30	TERMINATE AT 3:15PM, COOL TO AMBIENT BY 4PM.					
			10/1	REMOVE FROM HOT CHAMBER; PUT IN VAC. CH., HOOK UP TEST EQ.					
" "	8	FUNCT.	10/1	TROUBLE IN CURR. CIRCUITS; COMPL. ¶ 3.31 & 3.3.2 ABOUT 1:30PM					
				HOOK-UP REMOTE SW. CONTROL, FEED THRUS; HAVE TO LASH UP					
				ONE FOR ESVM; RIG PROBE OF WIRE, CU. TAPE & INSUL.					
" "			10/2	FINISHED SETUP ABOUT 10AM; CKD SOME PULLS & ESV					
				LOOKS GOOD. FRAYED THREAD REPLACED. DOOR LEFT OPEN.					
" "			10/5	CKD. PULLS W/O ANY CHANGE IN SET-UP - ALL POOR;					
" "		DIAGNOS.	10/5	REINSTALLED INSTRUMENTATION, REMOVED ESV PROBE & TRIED					
				EVERYTHING TO DIAGNOSE CAUSE. ESV INSIDE COVER HOLE					
				NORMAL, OUTSIDE RDG. OK, TABLE CURRENT LOW & FLUCTUATING.					
				ABOUT 2PM TWO READINGS OF 21 gr. WERE OBTAINED BUT					
				COULDN'T BE REPEATED. HUMIDITY SEEMS HIGHER THAN					
				LAST WEEK (NO DATA AVAIL.) CHAMBER LEFT OPEN.					
" "		DIAGNOS.	10/6	PULLS ARE NORMAL THIS AM. HUMIDITY RECORDER PUT IN					
				CHAMBER. REINSTALLED FLGT. CONFIG. INCL. ESV PROBE					
				WIRE (NOTE: AFTER PWR. ON, IT TAKES ESV ABOUT 10MIN.					
				TO BUILD UP). STILL DON'T KNOW CAUSE OF 0-8gr. PULLS					
				OF YESTERDAY. CONSISTANT TODAY, READY FOR FUNCT.					
				BUT HYD. SW. ACTUATOR MALFUNCTIONING - ADDED CK VALVES					
" "	11	FUNCT.	10/6	REPLACED FRAYED DISK SUSPENSION THD. W/FIBERGLAS (E.N. 826 pg. 71)					
				BEGAN TEST ABOUT 1:30 PM - PULLS AGAIN BELOW REQ'D MIN.					
" "		DIAGNOS.		BACK TO DIAGNOSTIC TESTS					
			10/7	NO PULL 1ST THING; EXPER. W/FGLASS THD. FRESH (DRY) - NO PULL;					
				DAMP - UP TO 21 gr.; MONOFIL. NYLON DRY - NO PULL, DAMP - VERY					
				LITTLE. (E.N. 826 pg. 72)					

MSFC - Form 2443-4 (June 1965)

QUALIFICATION TEST LOG

[illegible] / [illegible] HISTORY

ALLOWABLE OPERATING TIME	
CALENDAR LIFE	

LOCATION	EVENT NO.	EVENT SUBJECT	DATE	SUMMARY OF CHRONOLOGICAL EVENTS (TEST DOCUMENT NUMBER / TEST DESCRIPTION / NATURE & DESCRIPTION OF MALFUNCTIONS / SERIAL NUMBER OF REMOVED OR REPLACED PARTS / MODIFICATIONS / ADJUSTMENTS / REPAIRS / MAINTENANCE / SHIPPED / RECEIVED / ENVIRON. / ETC)	RUNNING TIME/OTHER (HOURS AND MINUTES) START	STOP	TOTAL TIME	CUM TOTAL	STAMP OR INITIAL
REL. TEST		DIAGNOS.	10-8	TESTED DISK CHARGE W/WET THD. VS. SPACE CHARGE: RATIO OF	[E.P. 526 p. 73]				
				5000 TO 500; INSTALLED NEW THD. (12# NYLON MONOFIL)					
" "	11	FUNCT.	10-8	¶ 3.3.1 & 3.3.2 STARTED ABOUT 1:40 PM — NO FORCES; SQUAWK					
				# 0040; CHAMBER PUMP-DWN BEGUN ABOUT 4 PM.					
" "			10-9	14 MICRONS @ 7:45, RAISE TO 5 PSI BY 8:14 AM. (SQ 0045 ON 10^{-4} PRESS.)					
" "	15	FUNCT.		¶ 3.3.1 & 3.3.2 ABOUT (8:23-10:30) — NO FORCE, ESV UP TO 24 KV					
				SQ# 0041; RAISED TO AMBIENT PRESS.					
" "	16	FUNCT.		¶ 3.3.1 & 3.3.2 ABOUT 9:00 AM — NO FORCE, ESV 20-21 KV.					
				SQ# 0042					
" "			10-12	DAY SPENT GETTING VIBR. FIXTURES TO FIT. REV. QCI FOR VIBR. SEQ.					
" "	18	FUNCT.	10-13	¶ 3.3.1					
" "	20	VIBR.	10-13	VEH. DYN. TEST-FLGT. AXIS; LARGE AMPL. NOTED @ SHIELD					
	21	INSTL		KNOB REMOVED TO GET TABLE IN ADJ. BKT.					
				SQ 0046 AGAINST EVENT #20 — UNABLE TO GET 3-5 CPS & MINOR					
				BOND BREAK AT BUCK/SHIELD INTERFACE; SHAKER FAILED					
			10-14	SHAKER DOWN ALL DAY — BLOWN PREAMP					
				2:30 PM PRIORITY LOST TO TANK JOB — SHAKER STILL DOWN					
			10-28	EVENTS 24 THRU 32 NOT RUN BECAUSE OF SHAKER LIMITS.					
" "	33			FUNCT. @ 9:20 AM; EVENT 35 @ 10:45; DURING EVENT 41					
				ROLL PIN ON ADJ. KNOB SHEARED FROM OVERTORQUE (SQ# 0046 pg 4)					
				FINISHED EVENT 50					
" "	51		10-29	COMPLETED EV. 51 THRU 68 TODAY					
" "	69		10-30	FINISHED EV. 77 BEFORENOON & 78 BY ABOUT 2 PM; STILL					
				NO FORCE, ESV. OK	TOTAL OPER. TIME DURING				
				UNIT RETURNED TO POTTING ROOM.	QUALIF. TEST = APPROX 77 HRS				
POTTING RM			11-13	DATA PACKAGE REVIEWED — ALL OPEN SQUAWKS SIGNED					
				OFF					
			11-16	MOVE TO SHIPPING DEPT.					

MSFC - Form 2443-4 (June 1965)